CURRICULUM

OF

BIOMEDICAL ENGINEERING

BACHELOR & MASTER
IN BIOMEDICAL ENGINEERING

2017

HIGHER EDUCATION COMMISSION
ISLAMABAD.

CURRICULUM DIVISION, HEC

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CONTENTS

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PREFACE

The curriculum, with varying definitions, is said to be a plan of the teaching-learning process that students of an academic programme are required to undergo to achieve some specific objectives. It includes scheme of studies, objectives & learning outcomes, course contents, teaching methodologies and assessment/ evaluation. Since knowledge in all disciplines and fields is expanding at a fast pace and new disciplines are also emerging; it is imperative that curricula be developed and revised accordingly.

University Grants Commission (UGC) was designated as the competent authority to develop, review and revise curricula beyond Class-XII vide Section 3, Sub-Section 2 (ii), Act of Parliament No. X of 1976 titled “Supervision of Curricula and Textbooks and Maintenance of Standard of Education”. With the repeal of UGC Act, the same function was assigned to the Higher Education Commission (HEC) under its Ordinance of 2002, Section 10, Sub-Section 1 (v).

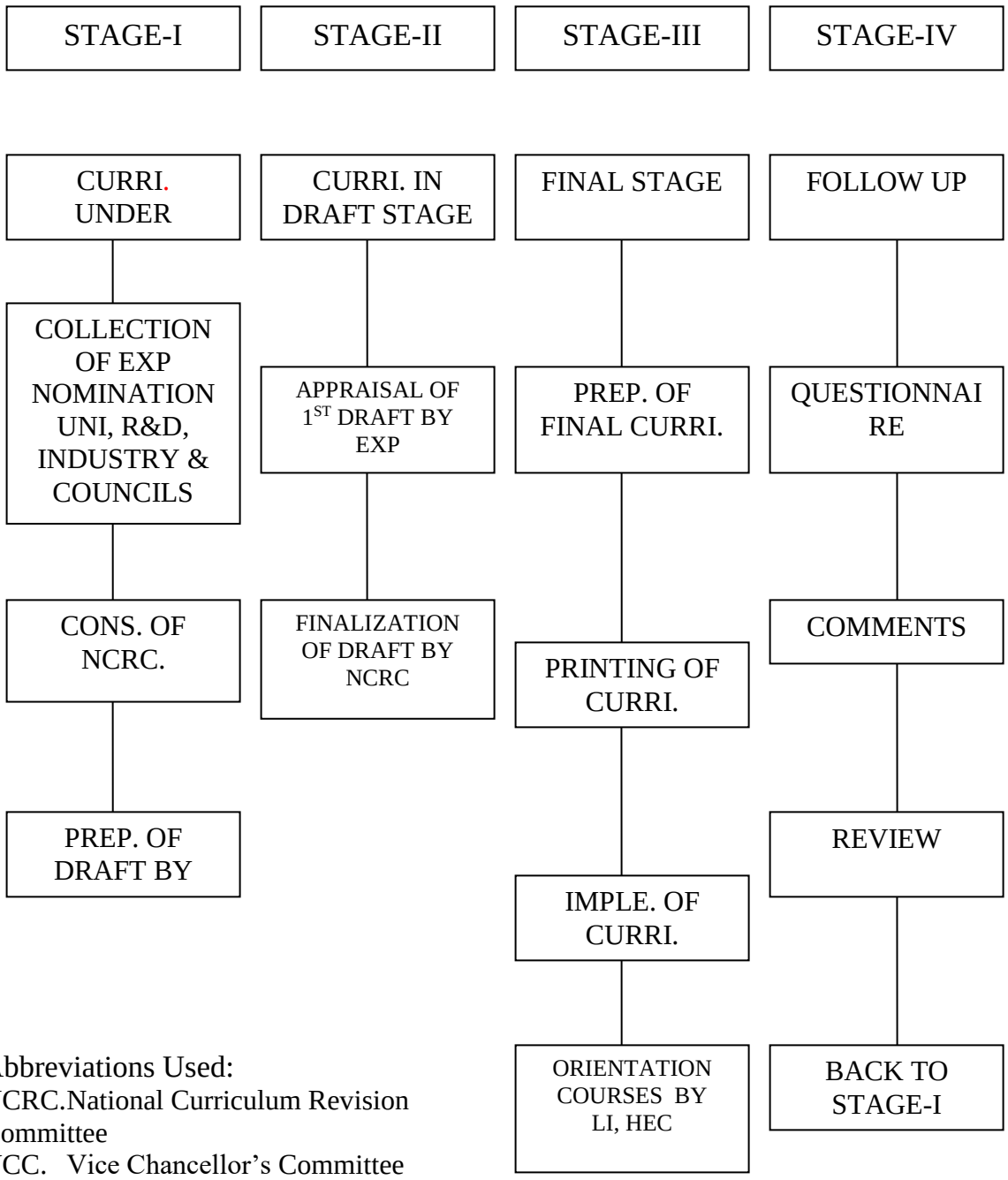
In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula regularly through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector universities, R&D organizations, councils, industry and civil society by seeking nominations from their organizations.

In order to impart quality education which is at par with indigenous needs and international standards, HEC NCRCs have developed unified framework/ templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering.

It is hoped that this curriculum document, prepared by the respective NCRC’s, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC
http://hec.gov.pk/english/services/universities/RevisedCurricula/Pages/default.aspx

(Muhammad Raza Chohan)
Director General (Academics)

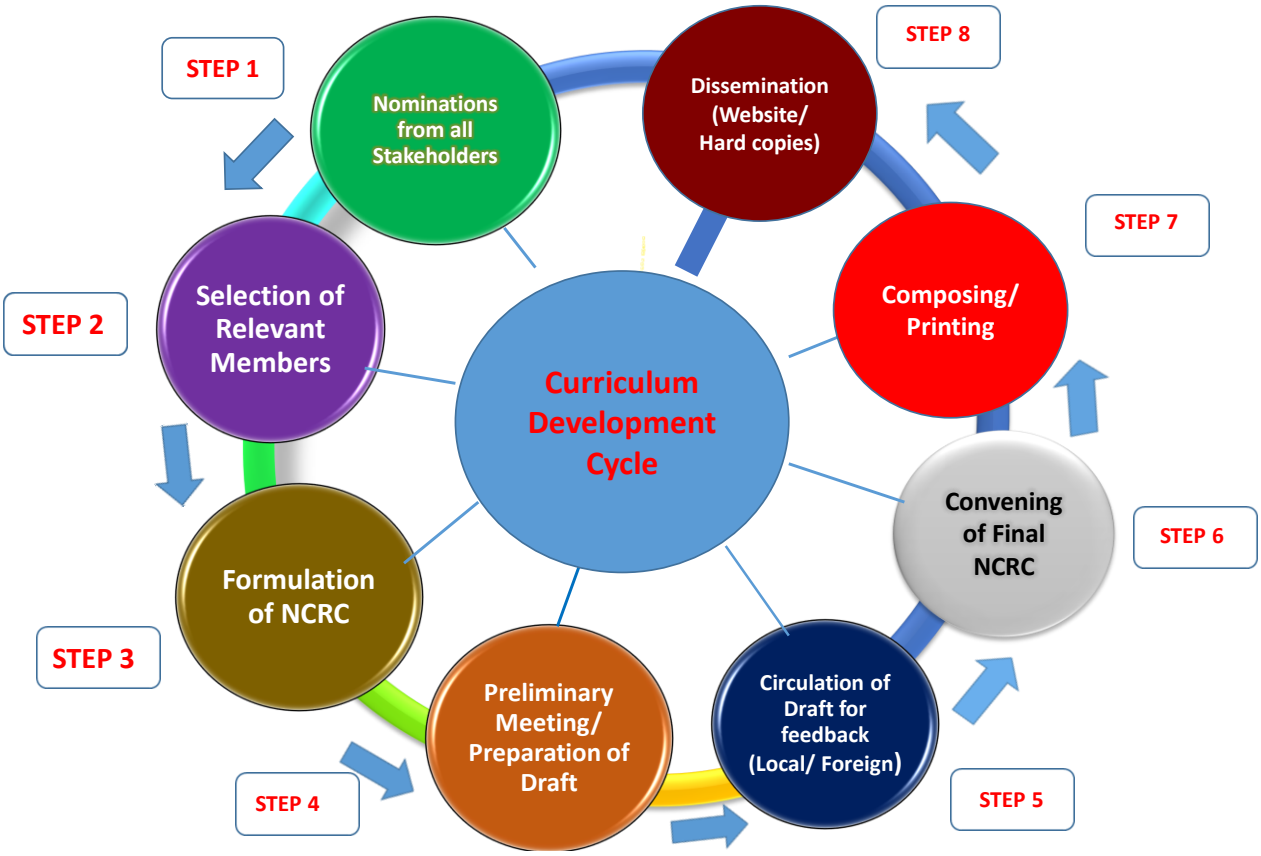
CURRICULUM DEVELOPMENT



Abbreviations Used:

NCRC. National Curriculum Revision Committee
VCC. Vice Chancellor's Committee
EXP. Experts
COL. Colleges
UNI. Universities
PREP. Preparation
REC. Recommendations
LI Learning Innovation
R&D Research & Development Organization
HEC Higher Education Commission
CONS: Constitution

CURRICULUM DEVELOPMENT CYCLE



INTRODUCTION

The final meeting of National Curriculum Revision Committee (NCRC) in the discipline of Biomedical Engineering for Bachelor and Master Degree programs was held from May 22-24, 2017 (03 days) at HEJ, University of Karachi, Karachi. Experts from academia and industry participated in the meeting. Dr. Muhammad Idrees (Director, Academics Division, HEC, Pakistan) coordinated the NCRC meeting. The list of the participants of final NCRC is as below:

S. No	Name & Institution	Position
1	Dr. Muhammad Nabeel Anwar Assistant Professor/HoD Department of Biomedical Engineering & Sciences, NUST, Islamabad.	Convener
2	Engr. Dr. Muhammad Zeeshan Ul Haque Associate Professor, Department of Biomedical Engineering, Barrett Hodgson University, The Salim Habib Campus, Korangi Creek, Karachi.	Co-convener
3	Engr. Dr. Muhammad Shafique **(PEC Nominee)** Associate Professor/HoD Department of Biomedical Engineering, Riphah International University, Islamabad.	Secretary
4	Engr. Prof. Dr. Bhawani Shankar Chowdhry **(PEC Nominee)** Professor, Faculty of Electrical Electronics & Computer Engineering, Mehran University of Engineering & Technology, Jamshoro.	Member
5	Prof. Dr. M. Inayatullah Khan Babar, Professor, Department of Electrical Engineering, University of Engineering & Technology, Peshawar.	Member
6	Mr. Muhammad Iqbal Bhatti, Dean / Principal, Ziauddin College of Biomedical Engineering, Ziauddin University, Karachi.	Member
7	Prof. Dr. M. A. Haleem Chairman/Professor, Department of Biomedical Engineering, Sir Syed University of Engineering & Technology, University Road, Karachi.	Member

8	Dr. Najib Azhar Professor/Dean of Biomedical Engineering Barrett Hodgson University, Karachi	Member
9	Engr. Dr. Zia Mohy Ud Din Associate Professor Sir Syed University of Engineering and Technology, Karachi	Member
10	Dr. Abdul Qadir Ansari, Assistant Professor, Department of Biomedical Engineering, Mehran University of Engineering & Technology, Jamshoro.	Member
11	Dr. Muhammad Abul Hasan, Assistant Professor, Department of Biomedical Engineering, NED University of Engineering & Technology, LEJ Campus, Karachi.	Member
12	Engr. Dr. Muhammad Arif **(PEC Nominee)** Assistant Professor, Department of Biomedical Engineering, Mehran University of Engineering & Technology, Jamshoro	Member
13	Engr. Narinder Parshad Chowdhry, Assistant Professor/Chairman, Dept. of Biomedical Engineering, Mehran UET, Jamshoro.	Member
14	Engr. Dr. Eraj Humayun Mirza Assistant Professor Sir Syed University of Engineering and Technology Karachi.	Member
15	Dr. Muhammad Idrees Director, Academics Division Higher Education Commission, Islamabad	Coordinator

List of members who attended preliminary meeting but could not attend final meeting due to their personal engagements during these dates:-

1	Brig. Syed Muhammad Tahir Zaidi, Professor, Department of Biomedical Engineering, National University of Medical Sciences, NUMS Secretariat, C/o Military Hospital, Rawalpindi.	Member
2	Engr. Dr. Nasir Mahmood Khan **(PEC Nominee)** Additional Registrar (Accreditation)	Member

	Pakistan Engineering Council, Ataturk Avenue G-5/2, Islamabad.	
3	Dr. Abu Zeeshan Bari, Assistant Professor, Department of Biomedical Engineering, NED University of Engineering & Technology, LEJ Campus, Karachi.	Member
4	Engr. Imtiaz Ahmed Engineer Technology Maintenance, Aga Khan Development Network, E-health Resource Center, Karachi.	Member

NCRC Agenda

The agenda of NCRC for Biomedical Engineering was as follows:

1. To revise/finalize the Biomedical Engineering curriculum (2012) for Bachelor and Master Programs according to indigenous needs and to bring it at par with international standards on Outcomes Based Education (OBE).
2. To revise/update/finalize preface/ preamble and rationale of the subject.
3. To revise and finalize program objectives, program learning outcomes (PLOs), teaching methods and assessment criteria (formative & summative).
4. To incorporate/suggest latest reading materials/references (local & international) for every course.
5. To revise/finalize course contents keeping in view the uniformity across other disciplines and avoiding overlapping.
6. To finalize recommendations for promotion/development of the discipline, keeping in view the futuristic needs of the society and international trends.

The meeting started with recitation from the Holy Quran. Dr. Muhammad Idrees, Director Academics, Education Commission, Pakistan welcomed the participants. All the participants introduced themselves highlighting their qualification, experience and area of expertise within the discipline of Environmental Engineering. Keeping with the tradition, Dr. Muhammad Idrees, Director Academics Division, HEC, Islamabad offered the house to opt the Convener and Secretary of the preliminary NCRC for smooth functioning which was unanimously agreed.

Dr. Muhammad Idrees presented the agenda and objectives of the final NCRC. He highlighted the importance of this meeting and emphasized for adaptation of general rules of curriculum development and revision like scope of the subject/program, horizontal & vertical alignment, rule of flexibility and adaptability keeping in view the futuristic approach, market value/job market and societal needs. He also shared a template for revising/finalizing the curricula.

The template was unanimously accepted to be followed. It was also agreed to add preamble, program objectives, program learning outcomes, teaching methodology and assessment segments in the curricula.

In next session, the house openly discussed the nomenclature of the discipline, preface, objectives of the program, program learning outcomes (PLOs), methods of instruction and learning environment, assessment and operational framework.

After long deliberation, the committee finalized the nomenclature, framework/scheme of studies, the duration of the program, number of semesters, number of weeks per semester, total number of credit hours, number of credit hours per semester, weightage of engineering and non- engineering courses and weightage of theory and practical of undergraduate 4-years program for Biomedical Engineering. Furthermore, list of courses (core & elective) and semester wise breakup of courses were also discussed thoroughly and the same was unanimously finalized.

In the afternoon session, admission criteria/intake criteria was discussed and finalized. After that the list of courses was distributed among the committee members keeping in view the experience and expertise in the field for reviewing course objectives, adding course learning outcomes, updating list of contents, adding teaching-learning methods and assessment, and updating bibliography/ references/ suggested books.

On second day, task assigned to the groups was displayed and discussed the addition/deletion and revising the courses. After thorough deliberation, draft curriculum of the undergraduate (4-years) program for Biomedical Engineering was finalized. In the evening session, the courses of postgraduate program was distributed among the members who were well versed and involved in this program.

On third day, the courses of postgraduate program of Biomedical Engineering was reviewed and after thorough discussion intake criteria, core and elective courses were finalized.

In the end, Dr. Idrees thanked the Convener, Co-convener, Secretary and all members of the Committee for sparing their time and for their contribution to prepare the revised draft of the curriculum. He further stated that their efforts will go a long way in developing workable, useful and market oriented comprehensive degree programs in Biomedical Engineering. The Convener of the NCRC also thanked the Secretary and members for their inputs in revising/updating the curriculum to make it more practical, competitive, efficient and realistic. The committee highly appreciated the efforts made by the officials of HEC Regional Centre, Karachi for making arrangements to facilitate the committee and their accommodation. The meeting ended with the vote of

thanks to Dr. Muhammad Idrees and his team from HEC for providing this academic and professional opportunity for national cause.

Recommendations by NCRC

1. Hospital/industry visits to be made more meaningful and related to Biomedical Engineering domain in the curriculum.

2. Since MBBS/BDS and other relevant disciplines do not have the pre-requisite to undertake Masters in Biomedical Engineering program. Therefore, other institutions may consider offering MS Biomedical Sciences or similar programs for MBBS/BDS and allied health and natural sciences streams.

3. PhD Biomedical Engineering program may be undertaken by the institution that fulfill HEC criteria for the same.

4. Biomedical Engineering Society of Pakistan (BEST) be established for developing collaboration among biomedical engineers and professionals and empower the community to promote the indigenous research and development of biomedical engineering equipment in the health care industry and society.

5. Regular seminars should be held at National level by the Biomedical Engineering Society of Pakistan under the umbrella of HEC/PEC through a formalized Outreach Program for all stakeholders **to increase awareness about Biomedical Engineering profession** and bring out the true potential of this discipline. The stakeholders includes students and academicians of schools, colleges, Universities and technical institutes as well as Administrative and professional staff, decision and policy makers of hospitals and healthcare delivery organizations and service providers including government and private healthcare departments, R&D Institutions, and the healthcare industry.

6. The outreach program and presentation seminars should be designed to help promote interaction and working relationships among the stakeholders.

7. Relevant regulatory bodies should require all hospitals to establish a department of Biomedical Engineering and employing qualified registered Biomedical Engineers.

8. Specialized journal in the field of Biomedical Engineering shall be launched under the patronage of HEC, Pakistan.

Rationale:

The Curriculum of Biomedical Engineering has vertical and horizontal alignments. The vertical alignments include placing/offering of basic and/or prerequisite courses in the initial semesters of a degree and those comprising advanced contents in the senior level semesters. The vertical alignments also address the issues of flow or linear advancement of knowledge from intermediate, undergraduate and graduate level degrees. The horizontal alignments include coherence of Biomedical Engineering with other Engineering disciplines.

Evaluation of students' performance will be based on Bloom's Taxonomy of Learning Domains comprising Cognitive, Affective, and Psychomotor. Evaluation scores of a course are proposed to carry 50% of the total marks in Final, 30% of the total theory marks in Mid, and 20% of the total theory marks in Semester work (including quiz, assignment, presentation etc...). The lab part of the course will be evaluated based on RUBRICS for Lab that will include i) Lab Reports, ii) Lab Demonstration, and iii) Viva Voce. The lab part of the course will be assessed as a total of 100 to be converted to the ratio of actual lab score for the number of specified credit hours.

Field visits may be made part of sessional marks wherever it deemed fit.

Mission Statement:

Producing competent Biomedical Engineers to effectively deliver real products and services for benefit to society, is a responsibility of universities/DAIs. The Biomedical Engineering Curriculum is designed to provide necessary knowledge, analytical and leadership abilities, critical thinking, and ethical values to the graduates to cope up with the technological challenges.

Preamble:

Program Educational Objectives (PEOs)

The program offered by the institution should also have well defined program objectives. Program educational objectives (PEO) are broad statements that describe what graduates are expected to achieve a few years after graduation. It should be ensured that the program objectives are aligned with the vision/mission of the institution. Program objectives should be articulated and made known to everyone in the institution through institutional publications and websites.

The successful pursuit and realization of the mission and objectives, and the means adopted to accomplish them bring out the quality of the institution and its programs. Program educational objectives are based on the needs of the program's constituencies and are linked to student learning outcomes and assessment process.

The objectives should be clear, concise, realistic and measurable within the context of the committed resources. A process should be developed to assess the level of attainment of the program objectives to evaluate effectiveness of the academic programs. It should include feedback from faculty, employers, alumni and other stakeholders. The evaluation results should be utilized for redefining/improving the program objectives.

The program must demonstrate that following are in place:

a) Well-defined and published Program Mission
b) Program's educational objectives defined and consistent with the mission
c) Program's educational objectives based on the stakeholder's needs on program
d) A process in place to evaluate the attainment of educational objectives
e) Evaluation results used for continual improvement of the program

The program of Biomedical Engineering will achieve the following PEOs;

PEO-1: Apply Biomedical engineering knowledge to identify and address the technical and societal problems.

PEO-2: Enhance students' intellectual and analytical abilities in taking initiative and/or developing innovative ideas for technological and professional growth in the field of Biomedical Engineering.

PEO-3: Work effectively as a team member or lead multidisciplinary teams while demonstrating the interpersonal and management skills and ethical responsibilities.

Program Learning Outcomes (PLOs)

Program learning outcomes are the narrower statements that describe what students are expected to know and be able to do by the time of graduation. These relate to the knowledge, skills and attitude that the students acquire while progressing through the program.

The program must demonstrate that by the time of graduation the students have attained a certain set of knowledge, skills and behavioral traits, at least to some acceptable minimum level. Specifically, it is to be demonstrated that the students have acquired the following graduate attributes:

The program learning outcomes of Biomedical Engineering will cover PLO 01-12.

PLO-01: Engineering Knowledge: Ability to apply knowledge of mathematics, science and engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

PLO-02: Problem Analysis: Ability to identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PLO-03: Design/Development of Solutions: Ability to design solutions for complex engineering problems and design systems, components, or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

PLO-04: Investigation: Ability to investigate complex engineering problems in a methodical way including literature survey, design and conduct of experiments, analysis and interpretation of experimental data, and synthesis of information to derive valid conclusions.

PLO-05: Modern Tool Usage: Ability to create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities, with an understanding of the limitations.

PLO-06: The Engineer and Society: Ability to apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solution to complex engineering problems.

PLO-07: Environment and Sustainability: Ability to understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

PLO-08: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PLO-09: Individual and Team Work: Ability to work effectively, as an individual or in a team, on multifaceted and/or multidisciplinary settings.

PLO-10: Communication: Ability to communicate effectively, orally as well as in writing on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentations, make effective presentations, and give and receive clear instructions.

PLO-11: Project Management: Ability to demonstrate management skills and apply engineering principles to one’s own work, as a member and/or leader in a team to manage projects in a multidisciplinary environment.

PLO-12: Lifelong Learning: Ability to recognize importance of, and pursue lifelong learning in the broader context of innovation and technological developments.

In addition to incorporating the graduate attributes (i) to (xii) listed above as the program learning outcomes, the educational institution may also include any additional outcomes if adopted.

Specific details relating to the processes adopted for assessing, evaluating and reviewing the program outcomes should be provided. The institution can also present the internal quality assessment cycle adopted by its Quality Enhancement Cell (QEC).

In particular, the program must demonstrate the following:

a) Well-defined and published Program Outcomes
b) Program Outcomes linked to the Program Objectives
c) Program Outcomes encompass desired outcomes listed above
d) Mapping of Program Outcomes to Course Learning Outcomes (CLOs)
e) Teaching-learning and assessment methods appropriate and supportive to the attainment of Course Learning Outcomes
f) Quality of assessment mechanism to evaluate achievement levels for all the Program Outcomes by each student
g) Process in place by which assessment results are applied to further refine the assessment mechanism and/or redefine the program / course outcomes, thus leading to continuous improvement of the program

The courses included in Biomedical Engineering programs are based on Course Learning Outcomes (CLOs) that necessitate that upon successful completion of the course, the student will;

a) **Understand** Biological Systems to recognize the Diagnostics and Therapeutics systems and **describe** the concept of techniques, accuracy, precision, and errors in all measuring instruments,
b) **Implement** procedures with the instruments used to measure different parameters; e.g., pressure, temperature, force, movement, Bio Fluid flow etc.,
c) **Show** the fundamentals of measurement systems by designing the protocol and necessary tools for this task,
d) **Operate** the instrument and analyze the output of the instrument,
e) **Demonstrate** the working principles of instruments and techniques for biomedical applications.

In the above statements, the underline verbs may be used in assessment tasks. With the help of this linkage we can find out achievement report of each CLO in final results. The course evaluators may use other key words mentioned in different levels of bloom's taxonomy.

Scope:

The scope of Biomedical Engineering Curriculum is based on existing needs of this discipline and a cushion for accommodation of courses / contents to address emerging / futuristic trends in the discipline of Biomedical Engineering. The role for Industry-Academia linkage to address problems faced by the industry and their indigenous solutions is also in the scope of this curriculum.

Curriculum and Learning Process:

The genesis of any engineering program is the fusion of its stakeholders' perceptions. The academic curriculum of the program is designed to facilitate / ensure the achievement of program outcomes by all students. This is achieved by offering a balanced combination of technical and non-technical contents coupled with appropriate assessment and evaluation methods. This has a well-defined core of essential subjects supported by requisite compulsory as well as elective courses. It also invokes awareness and comprehension of societal problems amongst the students and motivating them to seek solutions for improving the quality of life. The theory content of the curriculum is supplemented with appropriate experimentation / laboratory work.

The program structure is covering the essential fundamental principles at the initial stages, leading to integrated studies in the final year of the program, in consonance with the approach and levels defined in Bloom's taxonomy, particularly in breadth & depth courses.

The hallmark of a curriculum is to infuse original thinking, resourcefulness and entrepreneurial spirits among students. This program is embodying foundation courses as well as the general and specialized professional content of adequate Breadth and Depth, including appropriate Humanities and Science components. The program scheme is designed to ensure acquisition of knowledge and skills, encouraging necessary exposure to inter-disciplinary areas.

The contents of each constituent courses of the curriculum has been updated to absorb recent technological and knowledge developments as per international practices and to meet the national needs. Efforts are also made that there should also be an effective relationship between the curricular content and practice in the field of specialization.

It is expected that the graduates are able to demonstrate professional ethics and competence in oral communication, scientific & quantitative reasoning, critical analysis, system design, logical thinking, creativity and capacity for life-long learning.

The delivery of subject matter and the assessment process employed is expected enabling the students to develop intellectual and practical skills effectively, as deemed essential in program outcomes assessment. Complex engineering problems which are not easily quantifiable, e.g. communication skills (oral / written), critical thinking, ethics, team work, etc. often require rubrics as a tool for their assessment (both in direct or indirect methods).

In addition to regular teaching / learning activities such as classroom interaction, problem based learning (PBL) assignments, lab experimentation and faculty consultation, other aspects of student learning such as tutorial system, research / design projects, seminar / workshops and exposure to industrial practice should form an integral part of curriculum. Internal reviews of quality assurance procedures should be carried out periodically.

ELIGIBILITY CRITERIA:

For undergraduate level

Engineering education regulations of Pakistan engineering council should be adhered to for admission criteria and intake policy. Generally, the following criteria should be observed.

- For bachelors of biomedical engineering FSc. Pre-Engineering or Pre-Medical or equivalent securing at least 60% marks.
- A candidate who has passed the Diploma of Associate Engineer (DAE) Examination, securing at least 60% aggregate marks shall be eligible for applying in admission against reserved seats in relevant discipline of Engineering in which he or she has passed the DAE examination; and the relevancy of DAE will be as determined by Accreditation Committee of Pakistan Engineering Council; and (ii) A candidate possessing B.Tech (Hons)/BSc. Engineering Technology or equivalent qualification duly recognized by HEC seeking admission towards the relevant engineering discipline against 02% reserved seats of B.Tech (Hons)/BSc. Engineering Technology, shall be considered for admission in 2015 and after, with one year of exemption: Provided that the candidate possessing B.Tech (Pass), B.Tech (Hons) qualification recognized by HEC enrolled/ graduated upto 31st December, 2014 in relevant engineering discipline against reserved seats, with one year and two year of exemption respectively, shall be considered for registration with Pakistan Engineering Council.

Admission criteria for Master of Biomedical Engineering:

Bachelor in biomedical engineering or relevant engineering disciplines accredited by the Pakistan Engineering Council.

- Relevant engineering disciplines:
    - Mechanical
    - Electronics
    - Chemical
    - Telecommunication
    - Material
    - Electrical
    - Mechatronics
    - Computer
    - Software

FRAMEWORK/TEMPLATE FOR BACHELOR IN BIOMEDICAL ENGINEERING

Duration:	4 years
Number of semesters:	8
Number of weeks per semester:	16-18 (16 for teaching and 2 for examinations)
Total number of credit hours:	**138**
Number of credit hours per semester:	15-19
Engineering Courses:	70% (±5%)
Non-Engineering Courses:	30% (±5%)

Non-Engineering Domain									
Knowledge Area	Subject Area	Name of Course	Lec CH	Lab CH	C R	Total Cour-ses	Total Cre-Dits	% Area	% overa ll
Humanities	English	Communication Skills	2	0	2	2	5	14.29	3.63
		Technical Report Writing	3	0	3				
	Culture	Islamic Studies/Ethics	2	0	2	2	4	14.29	2.9
		Pakistan Studies	2	0	2				
	Social Sciences	Professional Practice & Ethics	3	0	3	1	3	7.135	2.17
Manage-ment Sciences		Entrepreneurship	3	0	3	2	6	14.29	4.35
		Engineering Management	3	0	3				
Natural Sciences	Physics	Applied Physics	2	1	3	1	3	7.135	2.17
	Mathema tics	Calculus and Analytical Geometry	3	0	3	3	9	21.43	6.52
		Linear Algebra & Differential Equations	3	0	3				
		Numerical Methods	3	0	3				
	Core	Complex Variables & Transforms	3	0	3	3	10	21.43	7.25
		Biochemistry	2	1	3				
		Basic Math/Biology	4	0	4				
TOTAL						**14**	**40**	**100**	**28.99**

- Total number of credit hours are flexible but it must meet PEC criteria.

Engineering Domain									
Knowledge Area	Subject Area	Name of Course	Lec CH	Lab CH	CR	Total Courses	Total Credits	% Area	% Overall
Computing	Fundamentals	Introduction to Computing	2	1	3	3	9	10.34	6.52
		Object Oriented Programming	2	1	3				
	Design	Modeling & Simulation	2	1	3				
Engineering (Biomedical) Foundation (Core)		Basic Electrical Engineering	3	1	4	9	27	31.04	19.56
		Physiology-I	2	1	3				
		Human Anatomy	2	1	3				
		Introduction to Biomedical Engineering	1	0	1				
		Physiology-II	2	1	3				
		Digital Logic Design	3	1	4				
		Circuit Analysis	3	1	4				
		Basic Electronics	3	1	4				
		Computer Aided Engineering Drawing	0	1	1				
Major Based Core (Breadth)		Probability and Statistics	3	0	3	6	22	20.69	15.94
		Biomedical Electronics	3	1	4				
		Biomedical Instrumentation-I	3	1	4				
		Signals and Systems	3	1	4				
		Microprocessor & Interfacing	2	1	3				
		Biomedical Signal Processing	3	1	4				
Major Based Core (Depth)		Biomechanics	3	1	4	3	12	10.34	8.7
		Biomedical Control Systems	3	1	4				

		Biomedical Instrumen-tation – II	3	1	4				
Inter-disciplinary Engineering Breadth (Electives)		Elective-I	3	0	3	7	22	24.14	15.93
		Elective –II	3	0	3				
		Elective-III	3	0	3				
		Biomaterials	3	1	4				
		Elective-IV	3	0	3				
		Elective-V	3	0	3				
		Medical Imaging	2	1	3				
Senior Design Project		Biomedical Engineering Project	0	6	6	1	6	3.45	4.34
Industrial Training			0	0	0				
TOTAL						29	98	100	71.01
Grand Total							138		100%

Summary				
Domain	**Knowledge Area**	**Total Courses**	**Total Credits**	**% Overall**
Non-Engineering	Humanities	5	12	28.99%
	Management Sciences	2	6	
	Natural Sciences	7	23	
	Sub Total	**14**	**40**	
Engineering	Computing	3	9	71.01%
	Engineering (Biomedical) Foundation (Core)	9	25	
	Major Based Core (Breadth)	6	23	
	Major Based Core (Depth)	3	9	
	Inter-Disciplinary Engineering Breadth (Electives)	7	25	
	Senior Design Project	1	6	
	Industrial Training	0	0	
	Sub Total	**29**	**98**	
Grand Total			**138**	**100**

Scheme of Studies
for Bachelor (4 Years) in Biomedical Engineering
Biomedical Engineering Curricula Under Uniform Framework

Semester I					
S. No.	**Code**	**Course Title**	**Theory**	**Lab**	**Combined**
1	BS-101	Applied Physics	2	1	3
2	CS-101	Introduction to Computing	2	1	3
3	EE-101	Basic Electrical Engineering	3	1	4
4	BS-102	Basic Mathematics	4	0	4
	BS-103	Basic Biology	4	0	4
5	BM-101	Introduction to Biomedical Engineering	1	0	1
6	HS-101	Pakistan Studies	2	0	2
Total Semester Credit Hours			**14**	**3**	**17**
Semester II					
S. No.	**Code**	**Course Title**	**Theory**	**Lab**	**Combined**
7	HS-102	Islamic Studies	2	0	2
8	BS-114	Calculus & Analytical Geometry	3	0	3
9	BM-112	Physiology I	2	1	3
10	EE-112	Circuit Analysis	3	1	4
11	CS-112	Object Oriented Programming	2	1	3
12	BM-113	Human Anatomy	2	1	3
Total Semester Credit Hours			**14**	**4**	**18**
Semester III					
S. No.	**Code**	**Course Title**	**Theory**	**Lab**	**Combined**
13	BS-211	Complex Variable & Transformation	3	0	3
14	BM-211	Physiology II	2	1	3
15	BM-202	Biochemistry	2	1	3
16	EE-211	Basic Electronics	3	1	4
17	CS-201	Computer Aided Engineering Drawing	0	1	1
18	HS-201	Communication Skills	2	0	2
Total Semester Credit Hours			**12**	**4**	**16**

Semester IV					
S. No.	**Code**	**Course Title**	**Theory**	**Lab**	**Combined**
19	BM-213	Biomedical Electronics	3	1	4
20	EE-212	Digital Logic Design	3	1	4
21	BS-212	Linear Algebra & Differential Equation	3	0	3
22	BM-214	Biomechanics	3	1	4
23	EE-213	Signals & Systems	3	1	4
Total Semester Credit Hours			**15**	**4**	**19**
Semester V					
S. No.	**Code**	**Course Title**	**Theory**	**Lab**	**Combined**
24	BM-311	Biomedical Instrumentation 1	3	1	4
25	BS-311	Probability & Statistics	3	0	3
26	BS-312	Numerical Methods	3	0	3
27	EE-311	Microprocessor & Interfacing	2	1	3
28	BM-312	Biomedical Signal Processing	3	1	4
Total Semester Credit Hours			**14**	**3**	**17**
Semester VI					
S. No.	**Code**	**Course Title**	**Theory**	**Lab**	**Combined**
29	BM-313	Biomedical Instrumentation II	3	1	4
30	BM-XXX	Elective I	3	0	3
31	BM-314	Biomedical Control Systems	3	1	4
32	CS-311	Modelling & Simulation	2	1	3
33	BM-315	Biomaterials	3	1	4
Total Semester Credit Hours			**14**	**4**	**18**
Semester VII					
S. No.	**Code**	**Course Title**	**Theory**	**Lab**	**Combined**
34	MS-401	Engineering Management	3	0	3
35	BM-411	Medical Imaging	2	1	3
36	BM-XXX	Elective II	3	0	3
37	BM-XXX	Elective III	3	0	3
38	HS-401	Technical Report Writing	3	0	3
39	BMP-402	Biomedical Engineering Project (Phase I)	0	3	3
Total Semester Credit Hours			**14**	**4**	**18**

Semester VIII					
S. No.	**Code**	**Course Title**	**Theory**	**Lab**	**Combined**
40	BM-XXX	Elective IV	3	0	3
41	HS-402	Professional Practices & Ethics	3	0	3
42	BM-XXX	Elective V	3	0	3
43	BMP-402	Biomedical Engineering Project (Phase II)	0	3	3
44	MS-402	Entrepreneurship	3	0	3
Total Semester Credit Hours			**12**	**3**	**15**
Total Credit Hours			**109**	**29**	**138**

Internship: A Hospital/Industry Internship after the completion of 6th Semester should be made mandatory during summer as part of the degree requirements.

List of Elective Courses:

The following may be offered as elective specialization courses according to the availability of resources in the respective educational institution.

Tack 1	Track 2	Track 3
Instrumentation	**Tissue Engineering and Molecular Bioengineering**	**Biomedical Computing**
Biomedical Engineering Systems	Biophysics	Telemedicine Systems
Medical Device Quality System and Standards	Biofluid Mechanics & Bioheat Transfer	Medical Data System
Medical Device Regulatory Affairs	Tissue Engineering	Computational Fluid Dynamics
Power Electronics	Genetic Engineering	Artificial Intelligence
Medical Robotics	Nano Biotechnology	Bioinformatics
Rehabilitation Engineering	DNA Computing	Medical Image Processing
Bioelectricity	Regenerative Medicine	Hospital Information System
	Drug Delivery Systems	
	Neuroscience	

DETAILS OF COURSES
FOR BACHELOR IN BIOMEDICAL ENGINEERING

Annexure-"A"

Applied Physics

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of common physical phenomenon relevant to biomedical engineering.	Cognitive	1	1
2.	**Explain** the basic laws of properties of matter, electricity and magnetism, optics, fluids, thermodynamics and sound.	Cognitive	2	1
3.	**Discuss** the applications of common physical phenomenon relevant to biomedical engineering.	Cognitive	2	1
4.	**Observe** the laws of heat and optics	Psychomotor	1	1
5.	**Practice** on equipment related to sound, fluid and electromagnetism	Psychomotor	3	1

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge	☐	7	Environment and Sustainability	☐
2	Problem Analysis:	☐	8	Ethics	☐
3	Design/Development of Solutions	☐	9	Individual and Team Work	☐
4	Investigation	☐	10	Communication	☐
5	Modern Tool Usage	☐	11	Project Management	☐
6	The Engineer and Society	☐	12	Lifelong Learning	☐

Course Outline:

1. **Properties of Matter**
    a. Elasticity and modulus of Elasticity
    b. Experimental determination of young's modulus
    c. Bending of beams
    d. Cantilever.
2. **Fluids**
    a. Steady and turbulent flow
    b. Bernoulli's theorem, Viscosity
    c. determination of Coefficient of viscosity by Poiseuillie's method
    d. Surface tension
    e. Surface energy
    f. Angle of contact
    g. Determination surface tension by rise in a capillary tube.
3. **Heat & Thermodynamics**
    a. Heat, Temperature, and Theories of heat
    b. Adiabatic and isothermal processes
    c. The four laws of thermodynamics
    d. Thermodynamic functions
    e. Efficiency of Heat Engines
    f. Carnot's Cycle
    g. Entropy
    h. Reversible Process and cycles
    i. Thermodynamic equilibrium
    j. Introduction to Heat transfer Mechanisms.
4. **Optics**
    a. Waves and Oscillations
    b. Simple Harmonic Motion
    c. types of wave motion
    d. Optics of light
    e. Interference
    f. Diffraction
    g. Polarization
    h. Double refraction
    i. Dispersion
    j. Types and uses of Deviation Lasers
5. **Electricity and Magnetism**
    a. Electric charges
    b. Electric field
    c. Electric potential
    d. Coulomb's law
    e. Gauss's law
    f. Capacitors and dielectrics
    g. Electric current
    h. Ohm's Law
    i. Magnetic properties of matter

j. Magnetic field
k. Magnetic force on current
l. Ampere's law, Faraday's law, and Lenz's law

6. Sound

a. Hearing and Echolocation
b. Ultrasound

Practical:

1. Study of Hook's Law
2. Measuring stress, strain and Young's Modulus of different materials
3. Study of Surface Tension and Viscosity of liquids
4. Study of Boiling points of liquids
5. Study of Gas laws
6. Venturi effect of liquids in motion
7. Heat transfer and entropy
8. Study of light, Color addition, Refection and Prism
9. Measurement of Snell's Law
10. Convex and Concave Lens
11. Study of reversibility and Dispersion of Light
12. Focal point and Magnification of Thin lens
13. Focal point and Magnification of Concave Mirror
14. Telescope and Microscope
15. Calculation of speed of Sound
16. Project : Construction of Telescope./Microscope

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Sessional (20%)
  Quiz (12%)
  Assignment (8%)
  Midterm(30%)
  Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. David Halliday, Robert Resnick and Jearl Walker, WIE Fundamentals of Physics, 7th ed. 2005, John Wiley & Sons, ISBN:0471465097
2. Arthur Beiser, " Schaum's Outline of Applied Physics, 4th ed. 2004, McGraw-Hill, ISBN:0071426116
3. Hobbie, Russell, Intermediate physics for medicine and biology-4th edition, 2007

Introduction to Computing

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of computer organization and **Understand** the concepts of System and Application programming.	Cognitive	2	1
2.	**Transforming** an engineering problem into computational frameworks (process of moving from a problem statement to a computational formulation) using DATA STRUCTURES, writing ALGORITHMs and Learning a language (preferably Python) for expressing the solution in computational/ programming framework.	Cognitive	3	2,5
3.	**Solve** individually the given engineering problem	Psychomotor	3	3,9,11

Course Outline:

1. **Introduction**
   a. Applications of Computers
   b. Classification of Computers
   c. Advantages and Disadvantages of Computers.
   d. Basic Components of a Computing Machine.
   e. Input and Output Devices
   f. Mass Storage Devices
   g. Ports, Buses and Expansion slots.
   h. Computer Networking Environment

2. **Data Storage**
   a. Data organization.
   b. Data representation in Computers.
   c. Physical and Logical Storage.
   d. Magnetic Storage Devices viz. RAM, ROM, Secondary Storage, Cache.
   e. Optical Storage Devices.

3. **Data Processing**
    a. Data Structures.
    b. Flow Charts.
    c. Process Flow Diagrams
4. **System and Application Programming**
    a. Basics of Operating Systems.
    b. Desktop and Network Operating Systems, Application softwares.
5. **Computer Programming**
    a. Introduction to High Level and Low Level Programming Languages.
    b. Process of Compilation and Interpretation.
    c. Data Types and Declaration.
    d. Header file and Linkage.
    e. Preprocessor Directives.
    f. Variables and Constants.
    g. Basic library functions.
    h. Input and Output Statements.
    i. Termination, Remarks.
    j. Control structures
    k. Repetition and loops.
    l. Arrays and String Operations
    m. Data Filling
    n. Using Graphics Libraries in Python/C++.
6. **Defining an Engineering Problem**
    a. Transforming Data in to Information.
    b. Using Computers to Solve an Engineering Problem.
7. **Semester Project- Group Activity**

Practical:

1. Working with Windows 8/10 and DOS.
2. Basic Computer Hardware Awareness and Troubleshooting
3. To begin Programming in Python/C++.
4. Preparing your PC for Python/C++.
5. Understanding Shell and IDLE in Python and/or C++ IDE.
6. Making small programs, do compilation, execution and debugging of programs.
7. Implementation of simple control structures.
8. Using Loops
9. Implementation of functions
10. Using user input and presenting output.
11. Arrays, multidimensional arrays
12. Working with strings, string functions.
13. Data Filling in Python/C++.
14. Using Graphics Libraries in Python/C++.
15. Open Ended Lab I
16. Open Ended Lab II

Teaching Methodology:

- Lecturing, Student Engagement
- Quizzes and Assignments, uploading suggested resources on course website.
- Semester Project

Suggested Assessment:

- **Theory (100%)**
  Sessional (20%)
    Quiz (12%)
    Assignment (8%)
  Midterm (30%)
  Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. Brian Williams and Stacey Sawyer, Using Information Technology, Latest Edition, McGraw-Hill, ISBN: 0072260718
2. William Stallings, Computer Organization and Architecture: Designing for Performance, Latest Edition , Prentice Hall, ISBN: 0131856448, ISBN-13: 9780131856448
3. Allen Downey; Think Python: How to Think Like a Computer Scientist; Green Tea Press Needham, Massachusetts.
4. David Beazley and Brian K. Jones, “PYTHON Cookbook”; O'Reilly Atlas.

Basic Electrical Engineering

Contact Hours:

Theory =48
Practical =48
Total =96

Credit Hours:

Theory =3.0
Practical =1.0
Total =4.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of matter and passive components of Electrical Circuit	Cognitive	1	1
2.	**Acquire** the basic knowledge of electrical network theorems	Cognitive	1	1
3.	**Solve, Analyze** and **Evaluate** the problems related to application of various network theorems	Cognitive	3	2
4.	**Acquire** the basic knowledge of transformers, single phase and poly-	Cognitive	1	1

	phase systems and its applications in Electrical Systems.			
5.	**Illustrate** knowledge of series and parallel circuit using various components	Psychomotor	2	1
6.	**Show** knowledge of constructing basic electrical circuits and demonstration of basic resistive and capacitive circuits	Psychomotor	4	2

Course Outline:

1. **Review**
   a. Structure of Matter, Conductors, Insulators and Semiconductors
   b. Electric Current, Electromotive Force (Voltage), Resistance, Conductance
   c. Conventional Current, DC and AC, Real and ideal Sources
   d. Ohm's Law
   e. Work, Energy and Power, Efficiency
2. **Resistive Network**
   a. Kirchhoff's voltage and current Laws
   b. Voltage and Current Source Conversion
   c. The Voltage-Divider Rule
   d. The Current-Divider Rule
   e. Series and Parallel Connected Sources
   f. Y-Delta Transformations
   g. Balanced Bridges
3. **Network Theorems**
   a. The Superposition Theorem
   b. Maximum Power Transfer Theorem
4. **Capacitance and Capacitors**
   a. The Nature of Capacitance
   b. Capacitor Dimensions and Dielectrics
   c. Capacitor Types
   d. Energy Stored in a Capacitor
   e. Transients in RC Networks
5. **Inductance and Inductors**
   a. Electromagnetic Induction
   b. Lenz's Law, Faraday's Transformer Action, Self-Inductance, Inductor
   c. Energy Stored in an Inductor
   d. Transients in RL Circuits
6. **Poly Phase Systems**
   a. Three phase circuits and balanced loads.
7. **Transformers and AC Machines**
   a. General principle working, fundamental equations, types, efficiency and losses.

Practical:

1. To get familiar with the usage of dual power supply and multimeter.
2. To study the resistor color code and measure the value of given resistors by the resistor color code chart and also study about the potentiometer.
3. To study the properties of series circuit and also find the calculated value and measured values of the given resistors.
4. To study the properties of parallel circuit and also find the calculated value and measured values of the given resistors.
5. To solve the given combination (series-parallel) circuit and find the values given in the observation table.
6. To study the properties of combination (series-parallel) circuit and also solving the given circuits.
7. To study the properties of combination (series-parallel) circuit and also solving the given circuits.
8. To analyze the given circuit using superposition theorem and find out the value of voltage and current across Resistor.
9. To solve the given circuit using superposition theorem and find out the voltage and current.
10. To determine by analysis the values VTH and RTH in a DC circuit containing a single voltage source.
11. To verify Norton's Theorem and the theory of source Transformation.
12. To study the different switching method.
13. To study the characteristics of the transformer.
14. To perform open circuit and short circuit testing of a transformer
15. To study the characteristics and working principle of DC motor.
16. To study the different Relay switches.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Sessional (20%)
  Quiz (12%)
  Assignment (8%)
  Midterm (30%)
  Final Term (50%)
- **Laboratory (100%)**

Text Book:

1. Basic Engineering Circuit Analysis, 8th Edition 2004 David Irwin ISBN-978-81-265-

Basic Mathematics

Contact Hours:

Theory =64
Practical =00
Total =64

Credit Hours:

Theory =4.0
Practical =0.0
Total =4.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Define** the several areas of mathematics	Cognitive	1	1
2.	**Understand** to articulate the difference between inductive and deductive reasoning and **Identify** the process of mathematical problem solving using a variety of techniques	Cognitive	2	1
3.	**Explain** the process of mathematical problem solving using a variety of techniques	Cognitive	2	1
4.	**Solve** different mathematical problems	Cognitive	3	1

Course Outline:

1. **Algebra**
   a. Complex Numbers
   b. Properties of complex numbers
   c. Conjugates and modulus
   d. Geometrical representation of complex numbers a+ ib.
2. **Quadratic Equations**
   a. Roots of a quadratic equation (real, distinct, equal and imaginary roots)
   b. Formation of quadratic equation when the roots are given
3. **Cube Root of Unity**
   a. Properties of cube root of unity; ω, ω^2, $1+ \omega + \omega^2 = 0$, etc.
4. **Matrices**
   a. Properties, sum, difference and multiplication of matrices
   b. Cramer's rule
   c. Solution of linear equations of three unknowns
5. **Determinants**
   a. Properties: addition, subtraction and multiplication of determinants
   b. Sequence and series
   c. Arithmetic progression
   d. Standard forms of an A. P.
   e. Arithmetic means
   f. Geometric progression
   g. Standard forms of a G. P.,

h. Sum of Infinite geometric series
i. Geometric means
j. Harmonic progression
k. Harmonic means
l. Relation between H.M., A.M. and G.M.

6. Binomial Expansion

a. Expansion of type $(a+b)^n$ for positive integer of 'n'
b. Use of the general term and determine the middle term or terms of the expansion.

7. Partial Fractions

a. Resolve into partial fractions
b. Proper and improper fraction

8. Functions:

a. One-one function
b. Onto function
c. Even function
d. Odd function
e. Exponential function
f. Trigonometric function
g. Logarithmic function

9. Circular Measure

a. Understand the definition of radians and use the relationship between radians and degrees.

10. Trigonometric Functions

a. Basic functions e.g. sine, cosine, tangent etc. relation between them
b. Trigonometric identities, sum and difference formulae, multiple angle formulae
c. Express type $\{a(\sin\theta) + b(\cos\theta)\}$ into $R\sin(\theta +- \varphi)$ etc.
d. Inverse functions

11. Differential Calculus

a. Limits: Basic concepts
b. Limit of form $\{(\sin\theta)/\theta\} = I$; when θ tends to zero.
c. Exponent functions and type a^x etc.

12. Differentiation

a. Differentiation of χ^n product and quotient formula
b. Trigonometric, exponents and logarithmic functions
c. Differentiation of implicit function, parametric function
d. Higher order Derivatives
e. Applications of differentiations
f. Minima and maxima
g. Tangent and normal velocity and acceleration
h. Rate of reaction

13. Integral Calculus

a. Basic Integration
b. Integrals of sum of powers of 'χ'
c. Trigonometric, exponent and logarithmic functions
d. Integration by parts: e.gχsinχ, χe^{x} and logχ etc.
e. Substitution method

14. Coordinate Geometry

a. Lines
b. Find length, mid-point, gradient of line segment, given the coordinates of end points
c. Different forms of equation of a line
d. Angle between two lines, distance of a point from a line

Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Sessional (20%)
  Quiz (12%)
  Assignment (8%)
  Midterm (30%)
  Final Term (50%)

Text and Reference Books:

1. FSC Maths Part I /II

Basic Biology

Contact Hours:

Theory =64
Practical =00
Total =64

Credit Hours:

Theory =4.0
Practical =0.0
Total =4.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the understanding of biology of human body	Cognitive	1	1
2.	**Describe** the role of enzymes in a human body	Cognitive	2	1
3.	**Define** the function of DNA, RNA with respect to human body.	Cognitive	1	1

4.	**Discuss** the application of Biology in biomedical engineering	Cognitive	3	1

Course Outline:

1. **Cell Structure and Function**
   a. Techniques used in Cell Biology
   b. Cell Wall and Plasma Membrane – The Boundary Wall
   c. Cytoplasm and Organelles
   d. Prokaryotic and Eukaryotic Cells

2. **Biological Molecules**
   a. Biological Molecules in Protoplasm
   b. Importance of Water (Importance in Protoplasm and in Environment)
   c. Carbohydrates
   d. Proteins
   e. Lipids
   f. Nucleic Acids
   g. Conjugated Molecules (Glycolipids, Glycoproteins, Lipoproteins and Nucleoproteins)

3. **Enzymes**
   a. Structure of Enzymes
   b. Mechanism of Enzyme Action
   c. Factors affecting the Rate of Enzymatic Action (Temperature, pH, Enzyme Concentration and Substrate Concentration)
   d. Enzyme Inhibition (Competitive and Noncompetitive Inhibitors)
   e. Classification of Enzymes

4. **Bioenergetics**
   a. Aerobic and Anaerobic respiration
   b. Mechanism of Respiration
   c. Synthesis of ATP – Chemiosmosis and Substrate-level Phosphorylation

5. **Biodiversity**
   a. Acellular life
   b. Prokaryotes
   c. Diversity among animals
   d. Digestion
   e. Circulation
   f. Immunity
   g. Respiration
   h. Homeostasis
   i. Support and movement
   j. Nervous coordination
   k. Chemical coordination

6. **Continuity in Life**
   a. Reproduction
   b. Development and aging
   c. Inheritance

d. Chromosome and DNA
e. Evolution

7. Application of Biology

a. Gene Cloning (Recombinant DNA Technology and Polymerase Chain Reaction)
b. DNA Sequencing
c. DNA Analysis
d. Genome Maps
e. Tissue culture
f. Transgenic bacteria, plants and animals
g. Biotechnology and healthcare
h. Scope and importance of biotechnology
i. Vaccination and integrated disease management
j. Animal husbandry
k. Latest techniques applied to enhance crop and fruit yields
l. Home gardening
m. Role of microbes in human welfare

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Sessional (20%)
  Quiz (12%)
  Assignment (8%)
  Midterm (30%)
  Final Term (50%)

Recommended and Text Books:

1. AS/A level Biology, Mary Jones, Contributors: Richard Fosbery, Jennifer Gregory, Dennis Taylor Edition 2, Cambridge University Press, 2007, ISBN 0521703069, 9780521703062
2. National Curriculum 2006, HEC Pakistan
3. AQA A-Level Biology, Pauline Lowrie, Mark Smith

Introduction to Biomedical Engineering

Contact Hours:		**Credit Hours:**	
Theory	=16	Theory	=1.0
Practical	=0	Practical	=0.0
Total	=16	Total	=1.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of Biomedical engineering	Cognitive	2	1
2.	**Describe** the applications of Biomedical Engineering with examples	Cognitive	2	1

Course Outline:

1. **Biomedical Engineering**
   a. What is biomedical engineering
   b. Branches of biomedical engineering
   c. Role of biomedical engineer
2. **Devices used in Biomedical Engineering**
   a. Biomedical instrumentation fundamental
   b. Critical care devices used in biomedical engineering
   c. Radiological instrumentation.
   d. Diagnostic biomedical devices
   e. Therapeutic Biomedical devices
3. **Applications of Biomedical Engineering**
   a. Rehabilitation Engineering
   b. Physiological modelling and simulation
   c. Biomedical signal processing
   d. Clinical Engineering
   e. Biomaterials
   f. Biomechanics
   g. Tissue Engineering and regenerative medicine
   h. Neural engineering
   i. Medical Image Processing

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Guest Speaker
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Sessional (20%)
  Quiz (12%)
  Assignment (8%)
  Midterm (30%)
  Final Term (50%)

Text and Reference books::

1. Introduction to Biomedical Engineering, 4th Edition, John Enderle
2. Biomedical Engineering Handbook Volume I & II, J. D. Bronzino

Pakistan Studies

Contact Hours:
Theory =32
Practical =0
Total =32

Credit Hours:
Theory =2.0
Practical =0.0
Total =2.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	Understand the historical perspective of Pakistan	Cognitive	1	8
2.	Understand the significant happenings that led to the creation of Pakistan	Cognitive	1	8
3.	Know about constitutional and political developments in Pakistan	Cognitive	1	12
4.	Understand about society, culture, land, people, economy and foreign policy of Pakistan	Cognitive	1	8

Course Outline:

1. **Historical Perspective**
   a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah.
   b. Factors leading to Muslim separatism
   c. People and Land
      - Indus Civilization
      - Muslim advent
      - Location and Geo-Physical features.
2. **Government and Politics in Pakistan, Political and constitutional phases**
   a. 1947-58
   b. 1958-71
   c. 1971-77
   d. 1977-88
   e. 1988-99
   f. 1999 onward
3. **Contemporary Pakistan**
   a. Economic institutions and issues
   b. Society and social structure
   c. Ethnicity
   d. Foreign policy of Pakistan and challenges
   e. Futuristic outlook of Pakistan

4. **Foreign Policy**
    a. Relations of Pakistan with neighbors
    b. Super powers
    c. Muslim world
5. **Human Rights**
    a. Conceptual foundations
    b. Local and international issues

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
    Sessional (20%)
        Quiz (12%)
        Assignment (8%)
    Midterm (30%)
    Final Term (50%)

Recommended Text and Reference Books:

1. Burki, Shahid Javed. State & Society in Pakistan, The Macmillan Press Ltd 1980.
2. Akbar, S. Zaidi. Issue in Pakistan's Economy. Karachi: Oxford University Press, 2000.
3. S.M. Burke and Lawrence Ziring. Pakistan's Foreign policy: A Historical analysis. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. Pakistan Political Roots & Development. Lahore, 1994.
5. Wilcox, Wayne. The Emergence of Bangladesh., Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. Pakistan Kayyun Toota, Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
7. Ziring, Lawrence. Enigma of Political Development. Kent England: Wm Dawson & sons Ltd, 1980.
8. Zahid, Ansar. History & Culture of Sindh. Karachi: Royal Book Company, 1980.
9. Afzal, M. Rafique. Political Parties in Pakistan, Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.

Islamic Studies

Contact Hours:

Theory =32
Practical =0
Total =32

Credit Hours:

Theory =2.0
Practical =0.0
Total =2.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	Illustrate Basic information and understanding of Islamic principles	Cognitive	3	12
2	Develop the skill of the students for understanding of issues related to faith and religious life.	Cognitive	5	8

Course Outline:

1. **Introduction to Quranic Studies**
   a. Basic Concepts of Quran
   b. History of Quran
   c. Uloom-ul-Quran
2. **Study of Selected Text of Holly Quran**
   a. Verses of Surah Al-Baqra Related to Faith (Verse No-284-286)
   b. Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
   c. Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
   d. Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
   e. Verses of Surah Al-Inam Related to Ihkam (Verse No-152-154)
3. **Study of Selected Text of Holly Quran**
   a. Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No. 6,21,40,56,57,58.)
   b. Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
   c. Verses of Surah Al-Saf Related to Tafakar, Tadabar (Verse No-1,14)
4. **Seerat of Holy Prophet (S.A.W) I**
   a. Life of Muhammad Bin Abdullah (Before Prophet Hood)
   b. Life of Holy Prophet (S.A.W) in Makkah
   c. Important Lessons Derived from the life of Holy Prophet in Makkah
5. **Seerat of Holy Prophet (S.A.W) Ii**
   a. Life of Holy Prophet (S.A.W) in Madina
   b. Important Events of Life Holy Prophet in Madina
   c. Important Lessons Derived from the life of Holy Prophet in Madina
6. **Introduction to Sunnah**
   a. Basic Concepts of Hadith
   b. History of Hadith

c. Kinds of Hadith
d. Uloom –ul-Hadith
e. Sunnah & Hadith
f. Legal Position of Sunnah

7. **Selected Study from Text of Hadith:**
8. **Islamic Law & Jurisprudence**
   a. Basic Concepts of Islamic Law & Jurisprudence
   b. History & Importance of Islamic Law & Jurisprudence
   c. Sources of Islamic Law & Jurisprudence
   d. Nature of Differences in Islamic Law
   e. Islam and Sectarianism
9. **Islamic Culture & Civilization**
   a. Basic Concepts of Islamic Culture & Civilization
   b. Historical Development of Islamic Culture & Civilization
   c. Characteristics of Islamic Culture & Civilization
   d. Islamic Culture & Civilization and Contemporary Issues
10. **Islam & Science**
    a. Basic Concepts of Islam & Science
    b. Contributions of Muslims in the Development of Science
    c. Quran & Science
11. **Islamic Economic System**
    a. Basic Concepts of Islamic Economic System
    b. Means of Distribution of wealth in Islamic Economics
    c. Islamic Concept of Riba
    d. Islamic Ways of Trade & Commerce
12. **Political System of Islam**
    a. Basic Concepts of Islamic Political System
    b. Islamic Concept of Sovereignty
    c. Basic Institutions of Govt. in Islam
13. **Islamic History**
    a. Period of Khlaft-e-Rashida
    b. Period of Ummayyads
    c. Period of Abbasids
14. **Social System of Islam**
    a. Basic concepts of Social System of Islam
    b. Elements of Family
    c. Ethical values of Islam

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Sessional (20%)
  Quiz (12%)
  Assignment (8%)

Midterm (30%)
Final Term (50%)

Text and Reference Books:

1. Hameed ullah Muhammad, “Emergence of Islam” , IRI, Islamabad
2. Hameed ullah Muhammad, “Muslim Conduct of State”
3. Hameed ullah Muhammad, ‘Introduction to Islam
4. Mulana Muhammad Yousaf Islahi,”
5. Hussain Hamid Hassan, “An Introduction to the Study of Islamic Law” leaf Publication, Islamabad, Pakistan.
6. Ahmad Hasan, “Principles of Islamic Jurisprudence” Islamic Research Institute, International Islamic University, Islamabad (1993)
7. Mir Waliullah, “Muslim Jrisprudence and the Quranic Law of Crimes” Islamic Book Service (1982)
8. H.S. Bhatia, “Studies in Islamic Law, Religion and Society” Deep & Deep Publications New Delhi (1989)
9. Dr. Muhammad Zia-ul-Haq, “Introduction to Al Sharia Al Islamia” Allama Iqbal Open University, Islamabad (2001).

Calculus & Analytical Geometry

Contact Hours:

Theory =48
Practical =0
Total =48

Credit Hours:

Theory =3.0
Practical =0.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the meanings and physical interpretation of functions, limits, integrations, derivatives, vector algebra and vector calculus	Cognitive	2	1
2.	**Solve** limits, higher derivative and integral problems **Solve** problems involving rates of change, optimization, and areas	Cognitive	3	1
3.	**Outline** the concept of limits, derivatives and integrals	Cognitive	4	2

Course Outline:

1. **Limits and Continuity**
   a. Introduction to Limits
   b. Rates of Change and Limits
   c. One-Sided Limits, Infinite Limits
   d. Continuity, Continuity at a Point, Continuity on an interval

2. **Differentiation**
    a. Definition and Examples
    b. Relation Between Differentiability and Continuity
    c. Derivative as slope, as rate of change (graphical representation).
    d. The Chain Rule
    e. Applications of Ordinary Derivatives
3. **Integration**
    a. Indefinite Integrals
    b. Different Techniques for Integration
    c. Definite Integrals
    d. Riemann Sum, Fundamental Theorem of Calculus
    e. Area Under the Graph of a Nonnegative Function
    f. Improper Integrals
4. **Transcendental Functions**
    a. Inverse functions
    b. Logarithmic and Exponential Functions
    c. Inverse Trigonometric Functions
    d. Hyperbolic Functions and Inverse Hyperbolic Functions
    e. More Techniques of Integration
5. **Analytical Geometry**
    a. Three Dimensional Geometry
    b. Vectors in Spaces
    c. Vector Calculus
    d. Directional Derivatives
    e. Divergence, Curl of a Vector Field
    f. Multivariable Functions
    g. Partial Derivatives
6. **Analytical Geometry**
    a. Conic Sections
    b. Parameterizations of Plane Curves
    c. Vectors in Plane, Vectors in space
    d. Dot Products, Cross Products
    e. Lines and Planes in Space
    f. Spherical, Polar and Cylindrical Coordinates.
    g. Vector-Valued Functions and Space Curves
    h. Arc-Length and Tangent Vector
    i. Curvature, Torsion and TNB Frame
    j. Fubini's Theorem for Calculating Double Integrals
    k. Areas Moments and Centers of Mass
    l. Triple Integrals, Volume of a Region in Space

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
  - Quiz (12%)
  - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)

Text and Reference Books:

1. Advanced Engineering Mathematics, by Erwin Kreyszig, 8th Edition
2. Calculus And Analytical Geometry, Schaum's Series

Physiology-I

Contact Hours:

Theory =32
Practical =48
Total =80

Credit Hours:

Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the fundamental concepts and methods of a life or physical science.	Cognitive	2	1
2.	**Apply** the systematic technique to explore natural phenomena, including hypothesis development, observation, experimentation, measurement, data analysis, and data presentation.	Cognitive	3	1
3.	**Recognize** the physiological principles of cells and tissue, and muscular, skeletal, immune, and nervous systems	Psychomotor	1	1
4.	**Use** the tools of a scientific discipline to carry out collaborative laboratory investigations.	Psychomotor	3	1

Course Outline:

1. **Introduction**
   a. The Cell and General Physiology
   b. Functional organization of human body and control of the internal environment
   c. Cell and its function, protein synthesis and cell reproduction

d. Metabolism of carbohydrates and formation of ATP
e. Lipid and Protein Metabolism, transport through Cell membrane

2. **Human physiology from a system's view point**
   a. Quantitative issues at the organ and whole body levels of Cardiovascular
   b. Respiratory
   c. Renal
   d. Digestive systems

3. **Nerve and Muscle**
   a. Membrane potential
   b. Action potential
   c. Excitation and Rhythmicity
   d. Contraction of Skeletal and cardiac muscles, sliding filament Mechanism, Heart as a pump

4. **Sensory Systems**
   a. Sensory Receptors
   b. Classification and basic mechanism of action

5. **Somatic Sensations**
   a. Mechanoreceptive sensations, pain, thermal and visceral pain, headache

6. **Special Senses**
   a. Eye, receptor function of the retina, Neurophysiology of Vision, the Chemical Sense-taste and smell

List of Practicals:

1. Use of stethoscope & measurement of human arterial blood pressure & pulse
2. Determination of Red Blood Cells per cmm of human Blood
3. Determination of White Cells per cmm of human blood
4. Determination of haemoglobin percentage in human blood
5. Physiochemical & microscope analysis of human urine sample (Renal System)
6. a) Demonstration of the use of ECG, b) Test of hearing
7. Determination of visual acuity of a human subject by using snellen's eye chart
8. Determination of bleeding time in human body
9. Determination of the coagulation time in human body
10. a) To record normal respiration & effect of System exercise on it using spirometer.
    b) To record normal respiration & effect of exercise on it using power lab.
    c) Introduction the organization & classification of neurons using neurolab System
11. a) To record normal respiration & effect of exercise on it using spirometer
    b) To record normal respiration & effect of exercise on it using power lab

c) Introduction the organization & classification of neurons using neurolab

12. To demonstrate the differential count of leukocytes in human blood Sample
13. To observe the shape of RBC in normal saline stem
14. To identify various parts of digestive tract & to observe cut mobility in exposed abdomen of dissected rabbit
15. To determine the group of blood sample

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. Physiology for Engineers: Applying Engineering Methods to Physiological Systems (Biosystems & Biorobotics) [Michael Chappell and Stephen Payne], ISBN:978-3319261959
2. Quantitative Human Physiology: An Introduction [Joseph J Feher], ISBN:978-0123821638
3. John E. Hall, Guyton and Hall Textbook of Medical Physiology, 13th Edition, ISBN: 9781455770052
4. Elaine N. Marieb, Essentials of Human Anatomy & Physiology, 11th Edition, ISBN: 9780321919007
5. Arthur B. Ritter, Physiology for Engineers: A Systems Approach, 2017, ISBN: 9781498734561

Circuit Analysis

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=48	Practical	=1.0
Total	=96	Total	=4.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** knowledge related to basic concepts, network laws and theorems used to analyze linear circuits.	Cognitive	1	1
2.	To **analyze** and understand the linear circuits using the network laws and theorems.	Cognitive	3	2
3.	**Describe** the behavior of energy storing elements and their transient response analysis.	Cognitive	2	2
4.	**Analyze** and **understand** the steady state response of resistive and reactive elements to AC excitation.	Cognitive	3	2
5.	**Illustrate** knowledge of primary electronic lab instruments including DMM, Function Generator, Oscilloscope and electronic trainer	Psychomotor	2	1
6.	**Show** knowledge of constructing electronic circuits and simulating their results using PSPICE	Psychomotor	3	2
7.	**Design** a basic electrical circuit and investigate effect of different changes on the final outcome	Psychomotor	4	2

Course Outline:

1. **The RLC Circuits**
   a. Source Free Series & Parallel RLC Circuits,
   b. over- damped, under-damped, critically damped RLC Circuits,
   c. complete response of RLC Circuits, Lossless LC Circuits,
   d. Power Factor Calculations

2. **The Sinusoidal Steady Response**
   a. Nodal, Mesh & loop analysis, Comparison between Nodal and Mesh Analysis
   b. AC source Transformation, Thevenin's, Norton's,
   c. Reciprocity & Compensation theorems. Maximum Power Transfer Theorem.
   d. First Order Circuits (RL and RC): Transient Response, Steady State Response, Unit Step Response

3. **Complex Frequency**
   a. Introduction to complex frequency damped sinosoidal forcing function, Z (s) & Y (s), frequency response as a function of s, Complex frequency plane, natural response & the S-Plane.

b. Voltage ratio synthesizing, Scaling & Bode Diagrams.
c. General Two Port Networks: Introduction, admittance parameters, some equivalent networks, impedance parameters, hybrid parameters, transmission parameters.

List of Practicals:

1. To determine the voltage of series circuit
2. To determine the voltage of parallel circuit.
3. To determine the current through mesh analysis
4. To determine the voltage across nodes through nodal analysis of the circuit
5. To determine the voltage across nodes through nodal analysis of the circuit
6. To determine the voltage across Resistor in the circuit.
7. To study the filter circuit and response
8. To study the response of an RC circuit when applied with a sudden dc voltage source.
9. To study the response of a Driven RC circuit when applied with a sudden dc voltage source.
10. To Study the response of Parallel Resonant Circuit
11. To study the response of Series Resonant Circuit
12. To study source free RLC circuit and determine its response mathematically and graphically
13. To determine the transient analysis and plot transient analysis of RL circuit using PSpise
14. To determine the transient analysis and plot transient analysis of RLC circuit using PSpise.
15. Determine Natural Response of an RLC circuit.
16. To study source free RL circuit and determine its response mathematically and graphically

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text book & Reference Books:

1. Engineering Circuit Analysis by William Hayt, 7th Edition, 2006. ISBN: 978-0073263182

2. Fundamentals of Electric Circuits by Charles K.Alexander, Matthew N. O. Sadiku. 4th Edition, 2008.ISBN 978-0077263195

Object Oriented Programming

Contact Hours:

Theory =32
Practical =48
Total =80

Credit Hours:

Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	To **Introduce** object-oriented programming paradigm in C++/Python.	Cognitive	1	1
2.	To **Discuss** basic concepts of OOP paradigm such as encapsulation, polymorphism, abstraction, inheritance, and data hiding.	Cognitive	2	2
3.	To **Transform** a complex engineering problem in to smaller, manageable and reusable programming objects.	Psychomotor	3	3
4	**Develop** program segments to solve complex engineering problems by isolating specialization, creating independent operating units and abstractions that allow communication with these units, but remove direct control over the independent units.	Psychomotor	3	9,11

Course Outline

1. **Introduction**
   a. Traditional trends in Programming, viz. procedural and structured programming.
   b. Object oriented programming Paradigm.
   c. Usefulness of OOP Paradigm.
   d. Characteristics of object-oriented languages.

2. **Object Oriented Programming Basics**
   a. Understanding core concepts
   b. Classes, Implementation of class and Objects.
   c. Objects as physical objects.
   d. Encapsulation.
   e. Directives
   f. Functions and Overloaded Functions

g. Reference arguments
h. Abstraction
i. Polymorphism
j. Object as data types constructor
k. Object as function arguments.

3. **User defined data types, Arrays and String Arrays fundamentals**
   a. User defined data types.
   b. Arrays of objects.
   c. Arrays as class Member Data
   d. Strings and String arrays.

4. **Inheritance**
   a. Concept of inheritance.
   b. Derived classes and Base classes.
   c. Derived Class Constructors.
   d. Member Functions
   e. Class hierarchies.
   f. Public and Private inheritance.

5. **Pointers, Streams and Data Filing**
   a. Addresses and Pointers.
   b. Address of operator and pointer and arrays.
   c. Stream classes.
   d. Stream Errors.
   e. Disk File I/O with streams.
   f. File pointers.
   g. Error handling in I/O file, with member function.
   h. Overloading the extraction and insertion operators.
   i. Memory as a stream object.
   j. Command line arguments, and printer output.

6. **Errors and Exceptions**
   a. A systematic, object-oriented approach to handling errors generated by C++ classes.
   b. Dealing example errors at runtime using Exceptions.
   c. Understanding Exceptional circumstance of Running out of memory
   d. Understanding Exceptional circumstance of Problems opening a file.

List of Practicals:

1. Revision of Loops.
2. Algorithm design based on loops and arrays.
3. Developing small programs using functions.
4. Experimenting operator overloading feature.
5. Developing classes and creating instances of Objects.
6. Developing Inherited classes
7. Designing user defined classes.
8. Experimenting OOP features such as Encapsulation
9. Experimenting OOP features such as Abstraction
10. Experimenting OOP features such as Polymorphism

11. Experimenting OOP features such as Handling runtime errors using Exceptions
12. Experimenting OOP features such as Directives
13. Revision of OOP features
14. Open ended lab I
15. Open ended lab II

Teaching Methodology:

- Lecturing, Student Engagement
- Quizzes and Assignments, uploading suggested resources on course website.
- Semester Project

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books::

1. **Object-Oriented Programming in C++** (Latest Edition); Robert Lafore, publisher SAMs.
2. C++: The Complete Reference, (Latest Edition) by Herbert Schildt, publisher McGraw-Hill.
3. C++ How to Program (Latest Edition) Edition by Paul Deitel, Harvey Deitel

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Human Anatomy

Contact Hours:		**Credit Hours:**	
Theory	=32	Theory	=2.0
Practical	=48	Practical	=1.0
Total	=80	Total	=3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the principle structures of major human organs and systems.	Cognitive	2	1
2.	**Understand** and **Describe** the basic anatomical structures associated with cells and tissue, and muscular, skeletal, immune, and nervous systems	Cognitive	2	1

3.	**Classify** and **Describe** the basic anatomical structures associated with the circulatory/cardiovascular, respiratory, urinary, endocrine, digestive, lymphatic systems.	Cognitive	2	1
4.	**Understand** the laboratory safety concern and how to apply safe practices in the laboratory.	Cognitive	3	1

Course Outline:

1. **Introduction**
   a. Anatomy and its branches
   b. Anatomical positions
   c. Planes
   d. Topography
2. **Cell Anatomy**
   a. Overview of Cellular Anatomy.
3. **Extremities (Upper and lower)**
   a. Bones
   b. Muscles
   c. Ligaments
   d. Tendons
   e. Bursae
   f. Reticulae
   g. Capsules
   h. Arteries
   i. Veins
   j. Lymphatic system
4. **Vertebral Anatomy**
   a. Vertebrae
   b. Pelvic girdle
   c. Spinal cord
   d. Nervous system
5. **Thorax-Thoracic Viscera**
   a. Surface anatomy
   b. Bones surface musculature
   c. Lungs
   d. Heart
6. **Abdomen**
   a. Organs location
   b. Structures
   c. Relations and function
7. **Head & Neck**
   a. Bones

b. Muscles
c. Cranial nerves

List of Practicals:

1. Demonstration of Human Skeleton in general.
2. Demonstration of basic structures in Human Anatomy (Skin, Muscles & Other Structures).
3. Demonstration of Anatomical planes & positions.
4. Demonstration of Movements & Motinal Terms.
5. Demonstration & Study of Scapula & Clavicle.
6. Demonstration & Study of Humerus bone.
7. Demonstration of Ulna and Radius.
8. Demonstration of wrist & hand bones.
9. Demonstration of Pelvic bone.
10. Study and demonstration of Femur bone.
11. Study and demonstration of Tibia & Fibula.
12. Demonstration of Foot bones.
13. Demonstration of skull.
14. Demonstration & study of different parts of Vertebral column.
15. Study and Demonstration of different Models.
16. Audio & Visual Demonstration of Human Anatomy.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference books:

1. Medical Terminology: A Living Language (6th Edition) [Bonnie F. Fremgen and Suzanne S. Frucht], ISBN: 978-0134070254
2. New Biology for Engineers and Computer Scientists [Aydin Tozeren and Stephen W. Byers], ISBN: 978-0130664631
3. Gerard J. Tortora, Principles Of Human Anatomy, 13th Edition, ISBN: 9781118344996
4. B. D. Chaurasia, BD Chaurasia's Human Anatomy: Vol. 1, 6th Edition, ISBN: 9788123923307
5. Frederic H. Martini, Human Anatomy, 8th Edition, ISBN: 9780321883322
6. Elaine N. Marieb, Human Anatomy, 8th Edition, ISBN: 9780134243818

7. Michael McKinley and Valerie O'Loughlin, Human Anatomy, 4th Edition, ISBN: 9780073525730

Complex Variable and Transforms

Contact Hours:
Theory = 48
Practical = 0
Total = 48

Credit Hours:
Theory = 3.0
Practical = 0.0
Total = 3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Define** the complex number systems and integral of complex functions	Cognitive	1	1
2.	**Explain** the concept of limits, continuity and differentiability of complex functions	Cognitive	2	1
3.	**Demonstrate** the concepts of integral transforms including Laplace Fourier transform and associated inverse transform	Cognitive	2	1
4.	**Analyze** different domain of transformation including Fourier and Laplace transformation	Cognitive	4	2

Course Outline:

1. **The complex number and complex variables**
   a. Complex differentiation and integration
   b. Laplace Transformation and its applications
   c. Series solution of the DEs
   d. Complex number systems and Complex Variable theory
   e. Introduction to complex number systems
   f. Argands diagram, modulus and argument of a complex number
   g. Polar form of a complex number
   h. De Moivres theorem and its applications
   i. Complex functions, analytical function, harmonic and conjugate harmonic functions
   j. Cauchy-Remann equations (in Cartesian and polar coordinates).
   k. Line integral
   l. Greens theorem
   m. Cauchys theorem
   n. Cauchys integral formula
   o. Singularities, poles, residue and contour integration and application

2. **Laplace Transforms**
   a. Laplace transforms of elementary functions

b. Properties of Laplace transform
c. Laplace transform of derivatives, integrals
d. Multiplication by t and division by t properties
e. Periodic functions and their Laplace transforms
f. Inverse Laplace transforms and their properties
g. Convolution theorem
h. Inverse Laplace transforms by integral and partial fraction methods
i. Heaviside expansion formula
j. Solution of ordinary differential equations by Laplace transform
k. Applications of Laplace transformation on various fields of engineering

3. Series Solution of Differential Equations

a. Introduction
b. Validity of series solution
c. Ordinary point, singular point
d. Forbenius method
e. Indicial equation
f. Bessels differential equation, its solution of first kind and its recurrence formulae
g. Logendre differential equation and its solution
h. Rodriguez formula

4. Fourier Transform

a. Fourier transform of simple functions
b. Magnitude and phase spectra
c. Fourier transform theorems
d. Inverse Fourier transform
e. Solution of differential equation using Fourier transform

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. Erwin Kreyszig, Advance Engineering Mathematics, 10th Edition, ISBN: 9780470458365
2. Robert L. Borrelli and Courtney S. Coleman, Differential Equations: A Modeling Perspective, 2nd Edition, ISBN: 9780471433323

3. Dennis G. Zill and Warren S. Wright, Differential Equations with Boundary-Value Problems, 8th Edition, ISBN: 9781111827069
4. Eric W. Hansen, Fourier Transforms: Principles and Applications, 1st Edition, ISBN: 9781118479148
5. J. F. James, A Student's Guide to Fourier Transforms: With Applications in Physics and Engineering, 3rd Edition, ISBN: 9780521176835
6. R. J. Beerends and H. G. ter Morsche, Fourier and Laplace Transforms, 2003, ISBN: 9780521806893

Physiology-II

Contact Hours:

Theory =32
Practical =48
Total =80

Credit Hours:

Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge about nervous system, Motor functions and endocrinology.	Cognitive	2	1
2.	**Describe** the basic physiological principles of nervous, endocrine, reproductive, and lymphatic systems.	Cognitive	2	1
3.	**Differentiate** the basic anatomical structures and functions associated with the nervous, endocrine, reproductive, and lymphatic systems	Cognitive	4	1
4.	**Recognize** the physiological principles of nervous, reproductive, endocrine and lymphatic systems	Psychomotor	1	1
5.	**Use** the tools of a scientific discipline to carry out collaborative laboratory investigations	Psychomotor	3	1

Course Outline:

1. **Nervous System**
   a. Organization of Nervous System
   b. Basic functions of synapses
   c. Neuronal Mechanism and circuits for processing information
2. **Motor Functions**
   a. Spinal cord and the cord reflexes
   b. The cerebral cortex and intellectual functions of the Brain
   c. Motor function of the Brain stem

d. Vestibular control of postural reflexes
e. Cerebrum and basal ganglia
f. Reticular

3. **Somatic Sensations**
   a. Mechanoreceptive sensations
   b. Pain
   c. Thermal and visceral pain
   d. Headache

4. **Behavioral functions of the Brain**
   a. Limbic System
   b. Role of the Hypothalamus
   c. Control of the vegetative functions of the body
   d. The Autonomic nervous system
   e. The Adrenal Medulla
   f. Electrical Activity from Brain

5. **Endocrinology and Reproduction**
   a. Introduction to Endocrinology and the pituitary Hormones;
   b. Hormonal functions in male and female

List of Practicals:

1. Study of kymograph
2. Recording of simple muscle twitch in Gastrocnemius sciatic nerve preparation
3. Recording of the effect of two successive stimuli on the nerve muscle preparation
4. Recording of the effect of continuous stimuli (fatigue) in a nerve muscle preparation
5. To demonstrate phenomenon of tentanisation
6. Effect of temperature on the simple muscle twitch
7. Demonstrate the superficial reflexes on a given subject
8. Demonstrate the deep reflexes on a given subject
9. To observe the receptor adaptation associated with Paccinian Corpuscle and other receptors in a computer simulated program
10. To illustrate the principle of phase locking in auditory fibers by using the compute simulated program
11. Determination of visual field in human subject.
12. Observe and study the spectrum and waveforms of different vowels sound and their relationship with the configuration of the vocal tract
13. Study the movement in basilar membrane during the passage of sound waves of different frequencies, on a simulated mode
14. (a) To calculate nerve conduction velocity from twitch records obtained by using a nerve-muscle preparation using Kymograph. (b) To calculate nerve conduction velocity from twitch records obtained by using a nerve-muscle preparation using powerlab. To locate the gustoreceptors in the human

15. (a) To calculate nerve conduction velocity from twitch records obtained by using a nerve-muscle preparation using Kymograph. (b) To calculate nerve conduction velocity from twitch records obtained by using a nerve-muscle preparation using powerlab. To locate the gustoreceptors in the human
16. Demonstration of the recording of an (extracellular) action potential from frog sciatic nerve (monophasic & biphasic) on oscillograph / oscilloscope
17. Study of reflex movements in spine of frog; Effect of acid treatment, Effect Effects of electric shock & Effect of Strychnine

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. Text book of Medical Physiology by Guyton and Hall (13th Edition).
2. Essential of Medical Physiology by Jaypee (6th Edition).
3. William F, "Review of Medical Physiology".

Biochemistry

Contact Hours:

Theory	=32
Practical	=48
Total	=80

Credit Hours:

Theory	=2.0
Practical	=1.0
Total	=3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** knowledge of biochemical and biophysical processes at molecular level.	Cognitive	1	1
2.	**Describe** the structure, classification and functions of protein and enzymes	Cognitive	2	1

3.	**Compare** metabolic pathways for diagnosis of metabolites in human body.	Cognitive	4	2
4.	**Analyze** structure and activity of biomolecules at cellular level.	Cognitive	4	2
5.	**Operate Under Supervision** to find Blood Glucose level with help of spectrophotometer	Psychomotor	3	1&2
6.	**Demonstrate** amino acid separation using chromatographic methods	Psychomotor	4	1&4

Course outline:

1. **Introduction to Biochemistry**
   a. Colloidal state, buffer, pH, significance of pH Henderson equation, surface tension, viscosity, osmosis, diffusion, Biological Membrane, active Transport, Chemi-osmotic theory-passive transport concept of chromatographic techniques (TLC, paper chromatography, GLC column chromatography etc.) carbohydrates, amino acids, nucleic acids, proteins, vitamins, enzymes, hormones & signaling agents.
2. **Metabolism of Carbohydrates, Lipids and Proteins**
   a. Carbohydrate Amino acids: structure, and properties. Proteins: primary and secondary structure of proteins. *Enzymes:* Nomenclature, properties, Working, Factors affecting Reaction, Equation and diseases Globular proteins: heme-proteins, hormones & signaling agents.
3. **Conformational analysis and forces**
   a. Conformational analysis and forces that determine protein and nucleic acid structure. Molecular Modeling of protein, nucleic Tertiary and quarterly structure of protein, protein mis- folding.
4. **Carbohydrates**
   a. Introduction, classification and structure. Digestion of carbohydrates. Metabolism of carbohydrates: glycolysis, regulation of metabolism, Overview and reactions of glycolysis, hormonal regulation of glycolysis, Tricarboxylic acid cycle, reactions of TCA, energy and regulation of TCA cycle.
5. **Bioenergetics**
   a. *Bioenergetics:* Thermodynamic principles in human body. Thermodynamics of phosphate compounds (phosphate transfer reactions) and role of ATP for biological energy transfer, thermodynamics of life
6. **Metabolism of Lipids**
   a. Digestion, absorption and secretion. Utilization of dietary lipids
7. **Vitamins**
   a. folic acid, VitaminB12, Vitamin C, Vitamin D, Vitamin B1, Vitamin A, Vitamin E.

List of Practicals:

1 How to prepare the Solution in Lab
2 Determination of pH by pH meter and Litmus paper
3 Demonstration the action of buffer
4 To determine the principle application of Hander son- Haselbash's equation
5 Tests for proteins
6 Examination of Egg white
7 Color reactions for proteins
8 Isolation of Casein from milk
9 Tests on carbohydrates
10 Measurement of Blood Glucose level with help of spectrophotometer
11 Oral Glucose Tolerance Test (OGTT)
12 Tests of Lipid profile by chemical analyzer
13 Separation of Amino Acids by chromatographic methods.
14 Open ended lab I
15 Open ended lab II
16 Open ended lab III

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. Lippincott, Bio-Chemistry 5th Ed,2010 Donald Voet, Judith, G. Voel and Charlotte, W. Prats,
2. Fundamentals of Biochemistry, 2006, John Wiley & Sons. Rodney Boyer,
3. Modern Experimental Biochemistry, Pearsons Education, Delhi, India. Tsai. C. Stan,

Basic Electronics

Contact Hours:
Theory =48
Practical =48
Total =96

Credit Hours:
Theory =3.0
Practical =1.0
Total =4.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Describe** and **explain** the basic construction, operation and characteristics of semiconductor devices	Cognitive	2	1
2.	**Apply** the acquired knowledge to solve small scale circuits consisting of semiconductor devices	Cognitive	3	2
3.	**Analyze** dc and ac response of small signal amplifier circuits using device models	Cognitive	4	2
4.	**Express** knowledge of primary electronic lab instruments including DMM, Function Generator, Oscilloscope and Electronic trainer to power up and evaluate Diode , BJTs and FETs based electronic circuits	Psychomotor	1	1
5.	**Investigate** the use of transistor and different passive electronic components in development of certain electronic solutions with possible variations to fine tune the output	Cognitive	3	2

Course outline:

1. **Semiconductor Theory**
   a. Introduction,
   b. Intrinsic and Extrinsic Semiconductors,
   c. Doping and energy levels.
2. **Diodes**
   a. PN junction/ Biased PN junction,
   b. V-I Characteristics,
   c. Load Line and dynamic resistance.
   d. Diode models, Reverse recovery time and temperature effects,

3. **Diode Applications**
   a. Half wave and Full wave rectifiers,
   b. Clippers and Clampers, Logic gates.

4. **Bipolar Junction Transistors**
   a. Construction, operation and characteristics,
   b. Amplifying action and variation in current gain,
   c. Common Emitter, Common Collector and Common Base Configurations. Power Ratings.

5. **BJT Biasing Circuits**
   a. Fixed Bias, Voltage Divider Bias and Emitter feedback Bias Circuits,
   b. DC load line and operating point,
   c. Biasing circuit design and stabilization, Transistor as a switch

6. **BJT Small Signal Analysis**
   a. Common Emitter Amplifier, Common Base Amplifier, Common Collector Amplifier, Amplifier Design and Loading effects,

7. **Field Effect Transistors**
   a. JFET Construction and Operation,
   b. Transfer characteristics and parameters,
   c. FET Biasing Circuits, Fixed Bias,
   d. Self-Bias and Voltage divider Bias

8. **Design of a bias circuit**
   a. FET Small Signal Analysis,
   b. JFET/Depletion MOSFET small-signal model,
   c. Common source, common drain and common gate amplifiers,
   d. Loading effects and design of amplifier circuits.

9. **Differential Amplifiers**
   a. Darlington transistor circuit, properties of differential amplifier stage,
   b. Circuits of differential amplifiers using BJTs and FETs.

10. **Oscillators:**
   a. Hartley oscillators,
   b. Colpitt oscillators,
   c. RC phase shift oscillators,
   d. Wein-Bridge oscillators,
   e. Crystal oscillators based on BJT and FET.

List of Practicals:

1 To observe the working of diode with forward and reverse bias.
2. Plot the diode characteristic curve.
3. Calculate the bulk resistance of the diode and observe its effect in the diode approximations.
4. To observe the working of half wave rectifier.
5. To observe the working of full wave rectifier
6. To observe the working of Bridge wave rectifier.
7. To observe the working of Zener Diode

8. To analyze the working of Clamper Circuit.
9. To analyze the wrking of Clipper Circuit.
10. To determine the output voltage for half wave voltage doubler.
11. To determine the output voltage for full wave voltage doubler.
12. To determine the output voltage for Zener limiting circuit
13. Checking and Troubleshooting the NPN and PNP Transistor using Multimeter.
14. To use the transistor in switching mode.
15. Demonstrate the operation and determine the biasing parameter of Base Bias Circuit.
16. Demonstrate the operation and determine the biasing parameter of Voltage Divider Bias Circuit.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text Book:

1. Electronic Devices and Circuit Theory By H. Boylestad and L. Nashelsky
2. Electronic Devices and Circuits By Theodore F. Bogart, Jr.

Computer Aided Engineering Drawing

Contact Hours:		**Credit Hours:**	
Theory	=0	Theory	=0.0
Practical	=48	Practical	=1.0
Total	=48	Total	=1.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of drawing skills and CAD drawings by **understanding** the concepts of basic drawing techniques and use them efficiently.	Cognitive	2	5

3.	**Demonstrate** individually the drawings of plan, elevation and cross sections of buildings and machine parts	Psychomotor	4	3

Course Outline:

1. **Introduction**
   a. Introduction to Engineering Drawing
   b. Use of drawing instruments and materials.
   c. Basic Tools- classification and brief description
   d. Lines, Types of lines, configuration of lines and their application, Selection of line thickness
2. **Engineering Geometry**
   a. Geometric construction
   b. Coordinate systems
   c. Basic entities
   d. Drawing simple geometric objects
   e. Introduction to different types of scales.
3. **Modelling Fundamentals**
   a. Introduction to solid modelling
4. **Multiviews and Visualization**
   a. Projection theory
   b. Projection of principal views from 3D models
   c. Orthogrpahic projections
   d. Isometric drawings
   e. Section views
5. **Dimensioning and plotting**
   a. Dimensioning
   b. Plotting and printing

Suggested Teaching Methodology:

- Lecturing
- Lab tasks
- Report Writing

Suggested Assessment:

- **Laboratory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)

Text and Reference Books:

1. A Textbook of Engineering Drawing: Along with an Introduction to AutoCAD (2015) by Roop Lal, Ramakant Rana

2. Mastering Autodesk Inventor 2015 and Autodesk Inventor LT 2015: Autodesk Official Press, Curtis Waguespack, ISBN: 978-1-118-86213-1
3. Engineering Drawing and Graphic Technology-International Edition, Thomas E. French, Charles J. Vierck, Robert J. Foster, McGraw-Hill, Inc.1993 ISBN 0-07-022347-5
4. Engineering Drawing and Design-Sixth Edition, C. Jensen, J.D. Helsel, D.R. Short, McGraw-Hill, 2002, ISBN 0-07-821343-6 (T 353 J47 2002)
5. Technical Drawing-Fourteenth Edition, F. E. Giesecke, A. Mitchell, H. C. Spencer, I.L. Hill, J.T. Dygdon, J.E., Novak, Prentice-Hall, Inc., 2012, ISBN 0-13-178446-3 (T 353 T43 2003)

Communication Skills

Contact Hours:

Theory =32
Practical =00
Total =32

Credit Hours:

Theory =2.0
Practical =0.0
Total =2.0

Course Learning Outcomes:

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

Sr. No.	CLO	Domain	**Taxonomy level**	**PLO**
1.	Demonstrate intermediate to advanced level English language skills extending from the Freshman English I course	Cognitive	**3**	**10**
2.	Exhibit an enhanced ability in the general verbal and non-verbal English language Communication Skills which can support real life Electronic engineering settings requiring team work and leadership skills.	Cognitive	**3**	**10**
3.	Demonstrate basic research skills and writing skills affiliated to research, to help them in writing research papers for the contemporary Engineering courses.	Cognitive	**3**	**10**
4	Make connections between the text, their own lives, and a variety of media.	Cognitive	**1**	**10**

Course Outline:

1. **Essay Writing and 7C's of Communication**
   a. Kinds of Essays
   b. Ways to Develop a Proper Beginning, Middle and Ending of Essay
   c. 7C's of Communication
2. **Use of Library and Internet Resources**
   a. Defining "The Library" and "The Internet"
   b. Researching in the library
   c. Researching on the internet

3. **Correction of Sentences and Question Tags**
    a. General rules of correction
    b. Examples
    c. Uses and Forms of Question Tags
    d. Procedure adding a Question Tag
4. **Précis Writing**
    a. Rules for Précis Writing
    b. Examples
5. **Verbal Communication: Strategies and Activities**
    a. Group Discussions
    b. Brainstorming
    c. Interviewing
    d. Creating a Newscast
6. **Paraphrasing**
    a. Introduction
    b. Uses of Paraphrasing
    c. Characteristics of a good Paraphrase
    d. Method of procedure
    e. Specimens
7. **Report Writing**
    a. Importance of Reports;
    b. Guidelines for Informal Report Writing;
    c. Informal Report Writing Practice sessions
8. **Curricula Vitae:**
    a. Introduction
    b. General Format
    c. Types of CV'
    d. Template for CV
    e. Optional Features
    f. Sample CV
9. **Minutes of Meeting**
    a. Introduction
    b. Meeting minutes Format
    c. Common Problems while taking Minutes of a Meeting
    d. Solution of Problems
    e. Sample Minutes of a Meeting
10. **Writing Memorandum**
    a. Introduction
    b. Audience and Purpose
    c. Format
    d. Sample Memo
11. **Resume Writing**
    a. What is Resume
    b. Kinds of Resume
    c. Role of a Resume

12. **Job Application Materials**
    a. Job Application Letter, Acceptance, Follow-up, and Recommendation Letters
    b. Examples and Practice Sessions
    c. Planning the Resume and Letter
13. **Presentations Skills**
    a. Individual & Group Presentation
    b. Teaching Presentation as a Skill
    c. Project Work on Power Point Presentations

Suggested Teaching Methodology:

- Lecturing
- Presentations
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)

Text and Reference Books:

1. Exploring The World Of English, Sadat Ali Shah
2. High School English Grammar & Composition P. C. Wren & H. Martin
3. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.
4. Writing. Intermediate by Marie-Chrisitine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
5. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).
6. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
7. Reading and Study Skills by John Langan
8. Study Skills by Riachard Yorky.

Biomedical Electronics

Contact Hours:
Theory =48
Practical =48
Total =96

Credit Hours:
Theory =3.0
Practical =1.0
Total =4.0

COURSE LEARNING OUTCOMES:

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

SR.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** single and multistage amplifiers at low and high frequencies. Construct and examine small signal and power amplifiers networks.	Cognitive	2	1
2.	**Analyze** various biomedical electronic circuits using operational amplifiers	Cognitive	4	2
3.	**Design** and construct data acquisition and signal conditioning circuits for biomedical applications. **Design** and construct active filters for biomedical signals.	Cognitive	5	3
5.	**Make a setup** for performing experimentation of different op-amp applications	Psychomotor	2	2
6.	**Develop** different analog signal processing circuits such as amplifiers, active filters, oscillators, etc.	Psychomotor	7	3

Course Outline:

1. **Operational Amplifiers**
   a. Analysis of OP-AMP action
   b. OP-AMP specifications
   c. Interpreting OP-AMP data sheet
   d. Offset voltage and current
   e. Temperature rating
   f. Output swing
   g. Gain, CMRR
2. **Basic OP-AMP Configuration Circuits**
   a. Inverting amplifiers
   b. non-inverting amplifiers
   c. Voltage follower
   d. Summing amplifiers
   e. Integrator and differentiator

3. **Instrumentational Amplifier**
    a. Sensing and Measuring with the instrumentation amplifier
    b. Instrumentation amplifier as a signal conditioning circuit
4. **Active Filters Design**
    a. Basic Low Pass filters
    b. Introduction to Butterworth filters
    c. High pass and Bandpass Butterworth filters
    d. Notch filters
5. **A/D and D/A converters**
6. **Selected Applications of OP-AMPs in Biomedical Engineering**
7. **Signal Acquisition and Conditioning of ECG using OP-AMPs**

List of Practicals:

1. Design and Analyze OP-AMP Based Inverting Amplifier
2. Design and Analyze OP-AMP Based Non-Inverting Amplifier
3. Design and Analyze the characteristics of Summing Amplifier
4. To study Characteristics of Differential Amplifier
5. To determine common mode rejection ratio (CMMR)
6. Design and Analyze OP-AMP Based Integrator
7. Design and Analyze OP-AMP Based Differentiator
8. Design and Analyze Instrumentation Amplifier
9. Designing an ECG Amplifier.
10. To Analyze Analog to Digital Converter
11. To Analyze Digital to Analog Converter
12. Designing and analyzing frequency response of Active Low Pass Filter
13. Designing and analyzing frequency response of Active High Pass Filter
14. Designing and analyzing frequency response of Active Band Pass Filter
15. Designing and analyzing frequency response of Active Band Stop Filter/
16. Project : ECG/EMG/ EOG/PPG Amplifier and filters

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
    Sessional (20%)
        Quiz (12%)
        Assignment (8%)
    Midterm (30%)
    Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. Electronics Design by Floyd 9th Edition
2. Operational amplifier and linear integrated circuits by Robert Coughlin

Digital Logic Design

Contact Hours:
Theory =48
Practical =48
Total =96

Credit Hours:
Theory =3.0
Practical =1.0
Total =4.0

COURSE LEARNING OUTCOME:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Explain** binary, hexadecimal numbers, different digital circuits	Cognitive	2	1
2.	**Solve** various fundamental problems related to Boolean algebra, digital logic gates, different combinational and sequential logic circuits	Cognitive	3	2
3.	**Design** various combinational & sequential logic circuits	Cognitive	5	3
4.	**Recognize** different types of digital integrated circuits (ICs)	Psychomotor	1	1
5.	**Arrange** discrete components for different types of combinational and sequential logic circuit**s**	Psychomotor	2	2
6.	**Construct** different types of combinational and sequential logic circuits	Psychomotor	7	3

Course Outline:

1. **Number Systems**
   a. Introduction to Digital Electronics, Why Binary Numbers?
   b. Binary to Decimal Conversion, Decimal to Binary Conversion,
   c. Hexadecimal Numbers, Hexadecimal to Binary Conversion,
   d. Decimal to Binary Conversion,
   e. BCD Numbers, The ASCII Code
2. **Logic Gates**
   a. Boolean operations such as NOT, OR, AND, XOR, NOR, NAND, XNOR
   b. Boolean algebra, DeMorgan's theorems, Two's complement of a binary number
3. **Simplification of Boolean Function**
   a. The Map Method such as Two and Three Variable Maps, Four Variable Map
   b. Product of Sums simplification
   c. NAND and NOR implementation
   d. Don't Care Conditions

e. The Tabulation Method

4. **Combinational Logic**
   a. Design Procedure
   b. Adders, Subtractors
   c. Code Conversion
   d. Analysis Procedure

5. **MSI and PLD Components**
   a. Decimal Adders
   b. Decoders and Encoders
   c. Multiplexers
   d. Read Only Memory
   e. Programmable Logic Array (PLA)
   f. Programmable Array Logic (PAL)

6. **Synchronous Sequential Logic**
   a. Flip-Flops, latches
   b. Triggering of Flip-Flops
   c. Analysis of Clocked Sequential Circuits
   d. State Reduction and Assignment
   e. Design Procedure

7. **Registers, Counters and the Memory Unit**
   a. Registers
   b. Shift Registers
   c. Ripple Counters
   d. Synchronous Counters
   e. Timing Sequences
   f. Random Access Memory (RAM)
   g. Memory Decoding

8. **Displays**
   a. Seven-segment Displays,
   b. Common Anode Display,
   c. Common Cathode Display,
   d. Seven-Segment Display Driver,
   e. Dot Matrix Displays,
   f. LED and LCD displays, Drivers for displays

9. **Introduction to Microprocessors**

List of Practicals:

1. Digital Logic Gates
2. Simplification of Boolean Functions
3. Combinational Circuits
4. Code Converters
5. Design with Multiplexers
6. Adders and Subtractors
7. Flip Flops
8. Sequential Circuits

9. Counters
10. Shift Registers
11. Serial Addition
12. Memory Unit
13. Clock Pulse Generator
14. Parallel Adder
15. Binary Multiplier
16. Asynchronous Sequential Circuits

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. M. Morris Mano, Digital Logic & Computer Design
2. D. J. Comer, Digital Logic and State Machine Design, Oxford University Press.
3. Victor P. Nelson, et al, Digital Logic Circuit Analysis and Design
4. Brian Holdsworth, Clive Woods, Digital Logic Design, Fourth Edition
5. M. Rafiquzzaman, Fundamentals of Digital Logic and Microcomputer Design, 5th Ed.
6. Tocci, Ronald J, Digital Systems principles and application. 10th Ed, 2009.

Linear Algebra & Differential Equations

Contact Hours:
Theory = 48
Practical = 0
Total = 48

Credit Hours:
Theory = 3.0
Practical = 0.0
Total = 3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** methods to resolve differential equations as they arise in engineering and science	Cognitive	2	1

2.	**Describe** the linear structure, existence, and uniqueness of solutions to differential equations	Cognitive	2	1
3.	**Solve** linear algebra problems	Cognitive	3	1
4.	**Outline** proofs of basic linear algebra results	Cognitive	4	1

Course Outline:

1. **Linear Algebra**
   a. Methods for solution of algebraic linear equations
2. **Vectors**
   a. Scalar and vector quantities
   b. Differentiation and integration of vector functions
   c. Gradient, Divergence and Curl
   d. Line integrals
   e. Green's Theorem
   f. Gauss theorem
   g. Divergence theorem
   h. Stokes' theorem
3. **Ordinary Differential Equations**
   a. Formulations
   b. Order, degree and linearity of differential equations
   c. Complementary and particular solutions, initial and boundary value problems
   d. Solution of Ordinary Linear Differential Equations of First Order
   e. Methods of solutions, Bernoulli's differential equations
4. **Linear Second Order Differential Equations**
   a. Characteristic equation and different types of it
   b. Methods of solving homogeneous linear differential equations with constant coefficients
   c. Particular solution by variation of parameter's method and solution by indeterminate coefficient method

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Sessional (20%)
  Quiz (12%)
  Assignment (8%)
  Midterm (30%)
  Final Term (50%)

Text and Reference Books:

1. Howard Anton, Elementary Linear Algebra, 11th Edition, ISBN: 9781118473504
2. Gilbert Strang, Introduction to Linear Algebra, 5th Edition, ISBN: 9780980232776
3. Sheldon Axler, Linear Algebra Done Right, 3rd Edition, ISBN: 9783319110790
4. David C. Lay and Steven R. Lay, Linear Algebra and Its Applications, 5th Edition, ISBN: 9780321982384
5. Bernard Kolman and David Hill, Elementary Linear Algebra with Applications, 9th Edition, ISBN: 9780132296540
6. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, ISBN: 9780470458365

Biomechanics

Contact Hours:

Theory =48
Practical =48
Total =96

Credit Hours:

Theory =3.0
Practical =1.0
Total =4.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Define** the basic knowledge of moving system mechanics with an overview of anatomical terminology, to **Describe** gross human movements.	Cognitive	2	1
2.	**Demonstrate** and **Analyze** the analytical problems related to human movements.	Cognitive	4	2
3.	**Design** individually the human limb components using software tool.	Psychomotor	4	5
4.	**Imitate** motion in upper and lower limbs using various biomechanical tools	Psychomotor	3	4&5

Course Outline:

1. **Introduction**
   a. Definition and perspective
   b. Review of statics
   c. Review of Dynamics
   d. Review of deformable body mechanics
   e. Viscoelasticity, material properties

2. **Anthropometry**
   a. Density, mass and inertial properties
   b. Direct measurement of anthropometric parameters
   c. Muscle anthropometry
   d. Mechanical advantage of muscle
   e. Multipoint muscles,

3. **Kinematics of Human Movement**
   a. Forms of motion
   b. Standard reference systems and joint movement terminology
   c. Spatial reference systems
   d. qualitative vs. quantitative analysis of human movement
   e. limb-segment angles, joint angle, linear and angular velocities and acceleration
   f. tools for direct/indirect measurement of kinematic quantities

4. **The biomechanics of Human Bone Growth and Development**
   a. Composition and Structure of Bone Tissue
   b. Material Constituents
   c. Structural Organization
   d. Types of Bones
   e. Bone Growth and Development
   f. Longitudinal Growth
   g. Circumferential Growth
   h. Adult Bone Development
   i. Bone Response to Stress
   j. Bone Modeling and Remodeling
   k. Bone Hypertrophy
   l. Bone Atrophy
   m. Osteoporosis

5. **Kinetics of Human Movement**
   a. Link segment models
   b. Joint reaction forces
   c. Direct Force measurements

6. **Biomechanics of upper & lower extremity**
   a. Loading and injuries to the shoulder, elbow, wrist joints.
   b. Loading and injuries to the Hip, knee and ankle joints

7. **Gait Biomechanics**
   a. Methods of gait analysis
   b. Gait cycle
   c. Temporal-spatial parameters
   d. Hip, knee and ankle joint kinematics and kinetics
   e. Interpretation of gait data

List of Practicals:

1. To determine the coordinates of the centre of gravity (COG) of a body using segmentation method.

2. To determine the centre of Gravity Measurement using Reaction Board
3. Volumetric analysis of irregular shaped body segments
4. To determine the muscle force required by the biceps while holding a known weight in hand for a range of elbow joint angles using the mechanical arm model
5. To determine the muscle force using an analytical model comprising two muscles at the elbow joint and compare the results with the previous one.
6. Design and develop a goniometer for upper limb.
7. Design and develop a goniometer for lower limb.
8. Design and develop a dynamometer for wrist.
9. Gait analysis among healthy individuals.
10. Dynamometry of human foot by virtue of body weight
11. Volumetric analysis of irregular shaped body segments
12. Analysis of human motion using Movement Velocity counter
13. Development of static human model using Visual 3D
14. Study of blood flow using blood vessel models
15. To design the human limbs on Solid works.
16. To analyse the human limbs on ANSYS.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. Susan J. Hall, Basic Bio-Mechanics, 6th Ed, 2011.
2. Margareta Nordin, Victor H. Frankel, Basic Biomechanics of the Musculoskeletal System
3. NihatÖzkaya, et al, Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation
4. David A. Winter, Biomechanics and Motor Control of Human Movement

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Signals and Systems

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=48	Practical	=1.0
Total	=96	Total	=4.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the types of signals and transforms techniques.	Cognitive	1	1
2.	**Classify** different types of signals and systems.	Cognitive	2	2
3.	**Apply** Laplace and Fourier Transforms to find the systems stability and frequency response	Cognitive	3	2
4.	**Imitate** Continuous time filters using modern tools.	Psychomotor	3	3,5

Course Outline:

1. **Signal and System Characteristics and Models**
   a. Concept of Continuous-Time and Discrete-Time Signals and Systems
   b. Basic Operations on Signals
   c. Signal and system classifications
2. **Time-Domain Representation of Continuous-Time Signals**
   a. Sinusoidal and Complex Exponential Signals
   b. Singularity Function Signals
   c. Signal Energy and Power
3. **Time-Domain Analysis of Continuous-Time Systems**
   a. System Impulse Response
   b. Continuous-Convolution Evaluation and Properties
4. **Frequency-Domain Representation of Continuous& Discrete-Time Signals**
   a. Spectra and Bandwidths of Continuous-& Discrete Time Signals
   b. Fourier Series Representation of Signals
   c. Amplitude and Phase Spectra of Periodic Signals
   d. The Fourier Transform and Spectra of Aperiodic Signals
   e. Properties of Fourier transform
5. **Frequency-Domain Analysis of Continuous-Discrete Time Systems**
   a. System Frequency Response
   b. Amplitude and Phase Responses
6. **Analysis of Continuous-Time Systems Using the Laplace Transform**
   a. Laplace Transform Evaluations and Theorems
   b. Evaluation of Inverse Laplace Transforms
   c. System Transfer Function and stability
7. **Continuous-Time Filters**
   a. Distortion-less Transmission
   b. Ideal Filters
   c. Approximation of Ideal Filters

d. Butterworth and Chebyshev Filter Design

List of Practicals:

1. To be familiarize with the MATLAB and SIMULINK.
2. To plot the sinusoidal, exponential and singularity functions
3. To perform the time-shift, time-scaling and time-reversal operations on the signals
4. To compute and plot the impulse response of the system
5. To compute the convolution of LTI Systems
6. To find the Laplace-Transform and inverse Laplace transform of the system
7. To find the transfer function and system stability
8. To plot the signals spectra using Fourier transform
9. To plot the frequency response of the system
10. To design filter using Butterworth & Chebyshev techniques
11. Open ended lab 1
12. Open ended lab 2
13. Open ended lab 3
14. Open ended lab 4
15. Open ended lab 5
16. Open ended lab 6

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. Gorden E. Carlson. Signal and Linear System Analysis. John Wiley & Sons, Inc. 2nd Edition. 1992.
2. Oppenheim, Alan V., and A. S. Willsky. Signals and Systems. Prentice Hall, 1982. ISBN: 9780138097318.

Biomedical Instrumentation-I

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=48	Practical	=1.0
Total	=96	Total	=4.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Define** principles and errors of measurements	Cognitive	1	1
2.	**Identify** sources of biopotentials	Cognitive	1	1
3.	**Analyze** various biomedical sensor and transducer characteristics	Cognitive	4	2
4.	**Describe** medical devices based on application to physiological systems	Cognitive	2	1
5.	**Analyze** the response of various biomedical instrumentation devices based on monitoring and recording processes	Cognitive	3	4
6.	**Observe** operation of commonly used biomedical instrument and sensors	Psychomotor	1	1
7.	**Design** different types of Biomedical instrument.	Psychomotor	7	3,5

Course Outline:

1. **Introduction to measurements**
   a. Precision
   b. Resolution
   c. Sensitivity
   d. Accuracy
   e. Uncertainty
2. **Bio-potentials, biosensors and transducers**
   a. Biomedical signals of the human body,
   b. Sensors and transducers for bio-potential measurements
   c. Problems encountered in measuring biopotentials of the human body
   d. Invasive and noninvasive measurement techniques and related equipment.
   e. Functional Building blocks of a Biomedical Instrumentation System
3. **Cardiovascular System Devices**
   a. Diagnostic: Electrocardiography, Measurement of Blood pressure, Blood flow
   b. Therapeutic: Cardiac output. Defibrillator, pacemaker
4. **Pulmonary System Devices**
   a. Diagnostic: Pulmonary Function Analyzer, Spirometry, Ventilation Monitors, Respiration: Pulse oximetry, Capnography,
   b. Therapeutic: Ventilators, Heart lung machine, nebulizer

5. **Musculoskeletal & Nervous System Devices**
    a. EMG
    b. EEG
6. **Critical Care Devices**
    a. Patient Monitoring**:** Patient Monitors, central monitoring system, telemetry system
    b. Surgical/Operation Theatre Devices Equipment**:** Electrosurgical unit
7. **Genito-urinary System Devices**
    a. Hemodialysis Machine
8. **Quality Assurance and Quality Control**
    a. Common defects in medical equipment
    b. Performance measurement
    c. Calibration
    d. Maintenance and repair

List of Practicals:

1. To study the principle of various Biomedical Transducer
2. To understand methods and instruments for body temperature measurement and compare temperature sensor for selection on the basis of their properties
3. To study the working of photo detectors/photo sensors and their application in biomedical
4. To study the techniques of measuring blood pressure and measure the systolic and diastolic pressure.
5. To become familiar with the electrocardiograph as a primary tool for evaluating electrical events within the heart and observe rate and rhythm changes in the ECG associated with body position and breathing.
6. To record maximum clench strength for right and left hands and correlate motor unit recruitment with increase skeletal force.
7. To record EMG response to increased weights lifted by dominant and non-dominant arms and to record EMG when fatigue is induced.
8. To observe respiratory cycle and record breath per minute and respiratory rate in different conditions eupnoea, hyperventilation and apnea Vera.
9. To record an EEG from an awake, resting subject with eyes open and eyes closed. Identify and examine alpha, beta, delta, and theta components of the EEG complex.
10. To record EOG on the horizontal plane and compare eye movements under the following conditions: pendulum tracking & pendulum simulation.
11. To observe respiratory cycle and record breath per minute and respiratory rate in different conditions eupnea, hyperventilation and apnea Vera.
12. To observe real time monitoring through multipara monitor/bedside monitor.

13. To Study the construction and working of x-ray equipment and to practice the safety aspect using standard procedure.
14. To practice the safety aspect of ultrasound machine using standard procedure
15. To observe the principle and working of ventilator.
16. Open ended lab 1

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Recommended Text and Reference Books:

1. Biomedical Instrumentation & Measures 2nd edition by Leslie Cromwell.1980. ISBN: 978-81-203-0653-0.
2. Bioinstrumentation by John G. Webster.2004.ISBN: 978-81-265-1369-7
3. Medical Instrumentation: Application and Design by John G. Webster.4th ed, 2010. ISBN: 978-0-471-67600-3

Probability and Statistics

Contact Hours:

Theory =48
Practical =0
Total =48

Credit Hours:

Theory =3.0
Practical =0.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** general understanding of probability and statistics	Cognitive	1	1
2.	**Apply** the concepts of statistics and probability on a data set	Cognitive	3	2
3.	**Practice** with software tools to **Analyze** the relevant data set.	Psychomotor	3	5

Course Outline:

1. **Descriptive Biostatistics**
   a. Introduction to Biostatistics,
   b. Measures of Central Tendency,
   c. Measures of Dispersion,
   d. Frequency Distribution,
   e. Graphical Methods (scatter plot, histogram, bar chart, stem-leaf plot etc.)
2. **Introduction to Probability**
   a. Multiplication and Addition Laws of Probability,
   b. Conditional Probability,
   c. Bayes' Rule and Screening Tests, Bayesian Inference
3. **Discrete Probability Distributions**
   a. Expected value and Variance of a Discrete Random Variable,
   b. Cumulative-Distribution Function of a Discrete Random Variable, Permutations and Combinations,
   c. Binomial Distribution,
   d. Poisson Distribution
4. **Continuous Probability Distributions**
   a. Normal Distribution,
   b. Properties of the Standard Normal Distribution,
   c. Normal Distribution Applications,
   d. Estimation of the Mean and Variance of a Distribution
5. **Sampling Distributions**
   a. Central Limit Theorem
6. **Hypothesis Testing**
   a. Hypothesis Testing (z-test t-test (one and two sample),
   b. chi-squared test),
   c. Analysis of Variance (ANOVA)(one-way & two-way),
   d. Regression analysis
7. **Statistical Software**
   a. Make appropriate use of statistical software (STATA, SPSS, MS-EXCEL etc.).

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Sessional (20%)
  Quiz (12%)
  Assignment (8%)
  Midterm (30%)

Final Term (50%)

- **Laboratory (100%)**

Texts and Reference Books:

1. Bernard Rosner, "Fundamentals of Biostatistics", 7th Edition, Brooks/Cole Cengage Learning.
2. Wayne W. Daniel, "Biostatistics: A Foundation for Analysis in the Health Sciences", 10th Edition, John Wiley & Sons, Inc
3. SPSS survival manual a step by step guide to data analysis using SPSS 4th edition by Julie Pallant.

Numerical Methods

Contact Hours:

Theory =48
Practical =0
Total =48

Credit Hours:

Theory =3.0
Practical =0.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Comprehend** the roots of an algebraic equation by numerical method	Cognitive	2	1
2.	**Solve** a differential equation using an appropriate numerical technique	Cognitive	3	1
3.	**Analyze** a definite integral using an appropriate numerical method	Cognitive	4	2
4.	**Evaluate** the solutions of linear systems of equations	Cognitive	6	2
5.	**Estimate** a function using a suitable numerical method	Cognitive	6	2

Course Outline:

1. **Error analysis**
   a. Floating points
   b. Errors and types of errors
2. **Solution of non-linear equation**
   a. Bisection,
   b. Regula-Falsi,
   c. Fixed-point iterative and Newton-Raphson's methods.
   d. Solution of linear algebraic equations.
3. **Direct methods**
   a. Crout's and Cholescky methods;

4. **Iterative methods**
   a. Jaccobi's and Guass-Seidal methods.
5. **Eigen values and eigen vectors**
   a. Characteristics equation and Power methods.
6. **Interpolations and extrapolations**
   a. Forward, backward, central difference operators and their relations.
   b. Newtons Forward, Backward and Divided Difference Interpolation Formulae.
   c. Lagrange's and Stirling's Interpolation Formulae.
7. **Numerical differentiation**
   a. Newton's-Forward and Backward differentiation Formulae.
8. **Numerical quadrature**
   a. Trapezoidal, Simpson's one-third, Simpson's three-eight and Weddle's rules and Gaussian quaderature.
9. **Solution of OD Eqns**
   a. Taylor Series, Euler's and its modified,
   b. Runge-Kutta, Miline's,
   c. Adam-Moltan (Predictor-Corrector) methods.
10. **Solution of Higher Order Differential Equations**
   a. Runge-Kutta methods.
   b. Solution of Partial Differential Equations by Finite Differences Methods (Explicit, Implicit and Crank-Niclson techniques) and ADI Method.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Sessional (20%)
  Quiz (12%)
  Assignment (8%)
  Midterm (30%)
  Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. Dunn, Stanley M, Alkis Conastantinides, Numerical Methods in Biomedical Engineering 2006
2. Canal and Chapra "Numerical Methods for Engineers".
3. Curits F. Gerald "Applied Numerical Analysis".
4. Erwin Kreyszig "Advanced Engineering Mathematics".
5. Chung Yau Lam "Applied Numerical Methods for the Solution of Partial Differential Equations"

6. Dr Saeed Akhtar Bhatti "A First Course in Numerical Analysis".
7. John L. Van Iwaarden "Ordinary Differential Equations with Numerical Techniques".

Microprocessor & Interfacing

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the fundamental knowledge / features and operation of contemporary microcontroller and microprocessor	Cognitive	2	1
2.	**Illustrate** the microprocessor / microcontroller based systems peripheral devices and systems at the chip level	Cognitive	3	2
3	**Develop** an assembly program and problem solutions in low-level programming	Cognitive	5	3
4.	**Try/ practice** compilers and assemblers from open source, third party, and microprocessor / microcontroller provider	Psychomotor	3	5
5.	**Show Agility** of the microprocessor**/** microcontroller using interfacing	Psychomotor	4	2, 3

Course Outline:

1. **Introduction to Microprocessor and Microcontroller**
   a. Microprocessor and its Architecture
   b. Simplified CPU / Memory Organization
   c. Addressing modes / Instruction Set Summary
   d. I/O port, pin diagram and functions
   e. Data Bus, Address Bus and Control Bus
2. **Using Assembly Language with C/C++**
   a. Introduction to Assembly programming
   b. I/O Programming
   c. Arithmetic and Logical Operations
   d. Program Looping and Subroutine
   e. Serial Port Programming

f. Interrupts Programming

3. **Data Acquisition Systems**
   a. Analog to digital converters and performance Parameters
   b. Designing of a Data Acquisition Systems
   c. Serial Communication
   d. Synchronous and Asynchronous Communication

4. **Interfacing Microprocessor/Microcontroller**
   a. Memory / Basic I/O interface
   b. RAM / ROM interfacing
   c. Keypad, Seven Segment / LED and LCD display
   d. Serial and Parallel ADC
   e. Sensor Interfacing
   f. Relays and Opto-isolators interfacing
   g. Stepper Motor Interfacing
   h. DC motor interfacing and PWM

5. **Defining an Engineering Problem**
   a. Introduction to embedded system chip board designing
   b. Component selection
   c. Troubleshooting and problem fixing

List of Practicals:

1. To demonstrate the hardware of microcontrollers and microprocessor
2. To use Proteus and Multisim simulating software for simulation
3. To use Keilmicro vision software for assembly and c programming
4. To generate List and Hex files
5. To interface and simulate ports of microcontroller (General)
6. To interface and simulate LEDs
7. To interface and simulate seven segments
8. To interface and simulate monochrome LCD
9. To program and perform ADC
10. To program and perform DAC
11. To connect external memory elements with microcontroller
12. To program and perform DC motor interfacing and PWM
13. To program and perform serial communication (RS232)
14. To program and perform parallel communication (RS232)

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Sessional (20%)
  Quiz (12%)
  Assignment (8%)

Midterm (30%)
Final Term (50%)

- **Laboratory (100%)**

Recommended Books:

1. Barry B. Brey, The Intel Microprocessor, 8th ed. 2009, ISBN-10: 0135026458
2. Roger L. Tokheim, Schaum's Outline of Theory and Problems of Microprocessor Fundamentals, Graw Hill Co., 1983, ISBN: 9780070649583
3. Douglas. V. Hall, Microprocessor and Interfacing, Programming and Hardware, Mc. Graw Hill Co., 1986
4. Scott Mackenzie, "The 8051 Microcontroller", Prentice Hall, ISBN: 0-13-780008-8
5. Muhammad Ali Mazidi, PIC Microcontroller and Embedded Systems, Pearson's Prentice Hall, 2008

Biomedical Signal Processing

Contact Hours:

Theory =48
Practical =48
Total =96

Credit Hours:

Theory =3.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** different techniques for the power spectrum processing of bio signals.	Cognitive	1	1
2.	**Differentiate** between frequency and time-frequency analysis methods.	Cognitive	2	1
3.	**Apply** signal processing techniques on bio-signals.	Cognitive	3	2
4.	**Analyze the** bio signals	Cognitive	4	2
5.	**Demonstrate** the concept of bio signal processing techniques to perform time and frequency domains analysis using modern tools.	Psychomotor	4	5

Course Outline:

1. **Introduction to Digital Signal Processing**
   a. Analog-to-Digital& Digital-to-Analog Conversion
   b. Digital Signals, Systems, and Difference Equations
   c. Realizations of Digital Systems

2. **Time domain Analysis**
   a. Digital Convolution
   b. Auto and Cross Correlation
3. **Discrete System Stability**
   a. The z-Transforms
   b. Transfer function, pole zero plot, and System Stability
4. **Discrete Time Fourier Transform**
   a. Frequency response of discrete system
   b. Frequency spectra of discrete signals
   c. Discrete Fourier Analysis and Periodic Signal Spectrum
   d. Fast Fourier transform (FFT),
5. **Finite Impulse Response Filter Design**
   a. FIR filter design using window method.
6. **Infinite Impulse Response Filter Design**
   a. IIR filter design using Bilinear Transformation Method
   b. IIR filter design using Pole-Zero placement, and Impulse Invariance methods.
7. **Biomedical Applications**
   a. Detection of Events: ECG rhythm analysis, Maternal Interference in Fetal ECG
   b. EEG wave-shape and wave-complexity: Analysis of event related potentials, coherence analysis, detection of EEG rhythms
   c. PPG wave analysis
   d. Sound wave analysis
   e. EMG Processing

List of Practicals:

1. Impulse and Step Responses
2. Convolution and Correlation
3. Z-transform, Pole-Zero Plot, Stability
4. Frequency response analysis
5. Frequency spectra analysis
6. FIR filter design
7. IIR Filter Design
8. Analysis of Filter behavior
9. Filter simulation
10. PPG Signal Analysis. Signal Peaks. Peak widths. Heart rate. SpO_2
11. ECG Waveform Analysis.
12. EEG Processing
13. Feature Extraction from EEG Signals.
14. Sound Processing. Detecting cardiac condition from digital stethoscope
15. Open ended lab 1
16. Open ended lab 2

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. Biomedical Signal Analysis, 2nd Ed, Ranagaraj M. Rangayyan, ISBN: 978-0-470-91139-6, Willey- IEEE Press.
2. Biomedical Signal Analysis: Contemporary methods and Applications, Fabian J, Theis and Anke Meyer, The MIT Press Cambridge, Massachusetts.
3. Biomedical Signal Processing: Principles and Techniques. D. C. Reddy.
4. Fundamentals of Digital Signal Processing. by: Joyce Van de Vegte.
5. Digital Signal Processing: Fundamentals and Applications. by: Li Tan, 2nd Edition.

Biomedical Instrumentation II

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=48	Practical	=1.0
Total	=96	Total	=4.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Describe** In-Vitro Diagnostic analysis of human samples	Cognitive	2	1
2.	**Use** of Microscopy, Spectroscopy & Chemical Analysis of human samples	Cognitive	3	4
3	**Analyzing** the results of Microscopy, Spectroscopy & Chemical Analyzers to identify various diseases	Cognitive	4	2
4	**Analyze** the impact of chemical safety and bio hazards on the environmental	Cognitive	3	7

5	**Acquire** knowledge of primary bio medical instrumentation devices	Psychomotor	1	1
6	**Practice** various safety aspects related to supervised operation of bio medical instrumentation devices	Psychomotor	3	7

Course Outline:

1. **Centrifugation techniques**
2. **Electrochemical methods of analysis**
   a. Electrophoresis
   b. Blood banking and transfusion
   c. Chromatography, Liquid chromatography
   d. Gas chromatography
   e. High performance liquid chromatography
   f. Clinical chemistry analyser
   g. Automated cell counter
3. **Spectroscopy**
   a. Spectrophotometry
   b. Flame photometry
   c. Mass spectrometry
   d. Infrared spectrometry
   e. Nuclear Magnetic Resonance Spectroscopy
4. **Microscopy**
   a. Electron microscopy
   b. Atomic force microscopy
   c. Confocal microscopy

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

List of Practicals:

1. Demonstration and Troubleshooting of centrifuge
2. Separation of Blood components using Centrifuge
3. Hemoglobin separation using Electrophoresis.
4. Design and Development of Virtual Instruments in Lab View.

5. Introduction to Virtual Instrument Designing in Lab View
6. Building Applications using For loops in Lab View
7. Signal Processing using Lab View
8. Analysis of Cerfiximetrihydrate using UV Spectrophotometer.
9. Determination of absorption coefficient using UV-spectrophotometer.
10. Wavelength analysis of different light sources using Atomic Spectrometer.
11. Demonstration and working of High Performance Liquid Chromatography (HPLC)
12. Demonstration and working of Hematology Analyzer.
13. Demonstration and working of Chemistry Analyzer
14. Troubleshooting and repair of Medical Equipment
15. Comprehension of documentation and hospital set-up
16. Open Ended Lab 1

Recommended Text and Reference Books:

1. Mary C. Haven (Editor), et al, Laboratory Instrumentation, 4th ed, 1995. ISBN: 978-81-265-2857-8
2. Cromwell, Bio-Medical Instrumentation & Measures 2. 2nd ed,1980. ISBN: 978-81-203-0653-
3. John G. Webster (Editor), Medical Instrumentation 2. 2nd ed. 2010. ISBN: 978-0-471-67600-3

Biomedical Control Systems

Contact Hours:

Theory =48
Practical =48
Total =96

Credit Hours:

Theory =3.0
Practical =1.0
Total =4.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the basic principles of control engineering.	Cognitive	1	1
2.	**Apply** various techniques to find the control system stability	Cognitive	3	2
3.	**Analyze** the performance of control systems.	Cognitive	4	2
4.	**Demonstrate** the concept of system stability and frequency response using modern tools.	Psychomotor	4	5

Course Outline:

1. **Introduction**
   a. Introduction to control systems

b. Open loop and close loop control systems.
c. Examples of control systems in Biomedical Engineering.

2. **Modeling in the Frequency Domain**
   a. Electrical/Electronic/Mechanical systems transfer function
   b. Electric circuits analog
3. **Modeling in the Time Domain**
   a. General State-Space Representation and Analysis
   b. Converting a Transfer Function to State Space & vice versa.
4. **Time Response**
   a. Poles, Zeros, and System Response
   b. Transient and steady state response of first and second order systems
5. **Reduction of Multiple Subsystems**
   a. Block Diagrams and reduction techniques
   b. Signal-Flow Graphs and Mason's Rule.
6. **Control System Stability**
   a. Routh-Hurwitz Criterion and Special Cases
7. **Root Locus Techniques**
   a. Root Locus and its Properties
   b. Sketching the Root Locus plots.
8. **Frequency Response Techniques**
   a. Bode and Polar Plots
   b. Stability via the Nyquist Diagram
   c. Gain Margin and Phase Margin

Lab Outline:

1. To be familiar with the Matlab programming and control system toolbox.
2. Find the closed-loop transfer function of the system.
3. To find the impulse and step responses of the control system.
4. To compute the transient response parameters of control systems.
5. To find the partial fraction residues and poles of the system.
6. To find the Eigen values of the system.
7. Transfer function to state space conversion.
8. To find the closed-loop pole locations to check the stability of the system.
9. To obtain the root locus of the system.
10. To obtain the Bode plot of the system.
11. To plot the Nyquist diagram of the system.
12. To find the gain and phase margins of the system
13. Open ended lab 1
14. Open ended lab 2
15. Open ended lab 3
16. Open ended lab 4

Suggested Teaching Methodology:

- Lecturing

- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. Control Systems Engineering, by: Norman S. Nise, 7th Edition.
2. Modern Control Engineering, by: Katsuhiko Ogata, 5th Edition.
3. Biomedical Applications of Control Engineering, by Selim S. Hacısalihzade

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Modeling and Simulation

Contact Hours:

Theory =32
Practical =48
Total =80

Credit Hours:

Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Explain** the concepts of basic Mathematical, Electrical, Fluidic Models, its analogous system	Cognitive	2	1
2.	**Analyze** the research problems by simulating the physiological models	Cognitive	4	2
3.	**Demonstrate** the modeling of cardiovascular system, blood flow, heat transfer, and renal clearance using simulation software tools	Psychomotor	4	5

Course Outline:

1. **Introduction**
   a. What is modeling and simulation
   b. Application of Modeling and Simulation in Biomedical Engineering
   c. Types of Models e.g. graphical model, Quantitative models, Multiscale Models
   d. Hybrid models and its application in Biomedical Engineering
   e. Conceptual modeling, why, when, where to use the conceptual model.

f. Conceptual model of cardiorespiratory system Subdivision of Physiology models and combining of basic elements of Conceptual models.
g. Things necessary before building a model.
h. One block model and its examples e.g. Heart, muscles, eye etc.
i. Hierarchical and integrated Model.

2. **Mathematical Models**
   a. Mathematical Models and their importance in biomedical engineering
   b. Mathematical models of Mechanical and Electrical systems.
   c. Electrical and fluidic modeling of the blood flow through the artery.
   d. Elementary Vascular Model and Its Electrical Analog
   e. Electrical modeling of physiological System
   f. Electrode electrolyte interface model

3. **Application of Modeling and Simulation in Physiological System**
   a. Modeling of physiological systems
   b. Examples of Physiological models
   c. Medical imaging and its importance in modeling and Simulation
   d. Importance of modeling and simulation according to new trends and technique
   e. Modeling of human organs using 3D printing
   f. Thermal modeling using Bio heat equations
   g. Factors effecting thermal models
   h. Application of thermal models on physiological System

4. **Software Implementations**
   a. Implementation of Biomedical models using software.

List of Practicals:

1. Introduction to modeling using software
2. Design of conceptual model
3. Modeling of cardiovascular system
4. Simulation of Bio heat equation
5. Modeling and simulation of blood flow
6. Modeling and simulation arterial plaque
7. Modeling heat transfer through skin
8. Modeling of electrical stimulation
9. Modeling of human organs
10. Heat simulation using RF coil and high intensity focused ultrasound
11. Modeling through medical images
12. Simulation of light propagation in the eye
13. Glucose and insulin regulation model.
14. Renal clearance modeling using compartmental model
15. Skin Absorption Model using Ficks's Law
16. Open ended lab 1

Suggested Teaching Methodology:

- Lecturing

- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. Modeling and simulation in biomedical engineering, Willem Van Meurs.
2. Physiological Modeling: An Introductory Course for Biomedical Engineers , John Enderle
3. Advances in Numerical Heat Transfer, Volume 3, W. J. Minkowycz.
4. Introduction to Modeling in Physiology and Medicine, Claudio Cobelli and Ewart Carson
5. Modeling and Simulation in Medicine, Frank C. Hoppensteadt, Charles S. Peskin,

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Biomaterials

Contact Hours:

Theory =48
Practical =48
Total =96

Credit Hours:

Theory =3.0
Practical =1.0
Total =4.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Identify** the classes of biomaterials.	Cognitive	1	1
2.	**Discuss** the properties of biomaterials for various biomedical applications	Cognitive	1	1
3.	**Apply** the understanding of biomaterial properties to **Design** medical implants.	Cognitive	3	1
4.	**Acquire** the knowledge for application of biomaterials for soft and hard tissues replacement and organ replacement, drug delivery, implants and adhesives.	Cognitive	1	1
5.	**Analyze** the physiological reference values among healthy and diseased	Cognitive	4	4

	individuals using spectroscopic techniques.			
6.	**Demonstrate** separation of bio-material (protein) by electrophoresis method	Psychomotor	4	4
7.	**Practice** fabrication of biomaterials for different biological tissues.	Psychomotor	3	3&9

Course Outline:

1. **Course Overview and Introduction**
   a. Introduction to biomaterials science
   b. Brief history of biomaterials (generations of biomaterials)
   c. Today's biomaterials applications: overview of types of implantable biomaterials and devices
2. **Properties of Biomaterials: General Concepts**
   a. Bonding, interatomic, intermolecular, surface interactions
   b. Introduction to bulk properties: microstructure, strength, deformation, thermal and optical properties
   c. Techniques: Introduction to surface Characterization of Biomaterials
   d. Electron spectroscopy for chemical analysis
   e. Attenuated total internal reflectance Fourier transform-infrared spectroscopy.
   f. Composite biomaterials
   g. 3D structure of biomaterials by bio X-ray diffraction, application of chitosan and other biopolymers in biomedical
3. **Classes of Materials Used in Medicine**
   a. Polymeric biomaterials (chitosan, collagen, elastin, proteoglycan and glycoperotein)
   b. basic principles: molecular and chemical structure, molecular weight and polydispersity
   c. physical behavior
   d. synthesis: addition, free-radical, condensation polymerization
   e. Hydrogels: structure and synthesis
   f. examples of biomedical hydrogels: acrylic, PVA, PEG, degradable, smart hydrogels
   g. Biological materials: structure and properties, hard tissues: tooth and bone, soft tissues: skin, blood vessel, tendon.
4. **Introduction to Mechanical Properties of Biomaterials**
   a. Review of static and dynamic properties: tensile, compressive, flexural, torsional, viscoelasticity, creep, dynamic modulus
   b. Deformation and fracture of engineering materials
   c. Biomechanics of arthroplasty
   d. Introduction to finite element analysis.
5. **Biomaterials Degradation in the Biological Environment**
   a. Review of clinical cases of implant failure

b. Mechanisms of metallic corrosion
c. Fatigue failure
d. Wear
e. Polymer degradation
f. Ceramic degradation

6. **Biocompatibility**
   a. Biological responses to biomaterials
   b. Toxicity and hypersensitivity
   c. Blood-material interactions
   d. Tumours associated with biomaterials and implants
   e. Biofilms
7. **Special Considerations for Implants, Devices and Biomaterials**
   a. Sterility and patient safety
   b. Device Failure Mode Analysis/Risk Analysis
   c. Voluntary consensus standards and regulatory compliance
   d. Legal aspects of biomaterials, clinical trials and case studies in regulations
8. **Tissue Engineering, gene therapy using viral vector materials for scaffolding.**
9. **Biomaterial implantation and Acute inflammation**
10. **Wound healing and the presence of biomaterials**
11. **Immune response to biomaterials**
12. **Biomaterials and thrombosis**
13. **Infection, tumorogenesis and calcification of biomaterials**

List of Practicals:

1. To build molecular model of a biopolymer from basic repeating peptide units
2. Molecular graphics of basic repeating units of biopolymer
3. Interpretation of bio X-ray diffraction of a biomaterial expected diffraction pattern
4. Calculate R-value for structural analysis of biopolymers
5. To build model of CHITOSAN (bio-materials) from basic repeating units.
6. Molecular graphics of basic repeating units of CHITOSAN.
7. Demonstration of features of dental chair & dental operatory.
8. Demonstration of bio-materials (bioceramics, porcelain & metals) its composition & properties
9. Demonstration of the process of sterilization, autoclave & X-ray unit (dental).
10. Separation of bio-material (protein) by electrophoresis method involved in various diseases.
11. Demonstration of different types of sutures.
12. Fabricate a biomaterial for bone tissue
13. Fabricate a biomaterial for dental tissues
14. Tension and compression analysis for fabricated biomaterials.
15. Open ended lab 1
16. Open ended lab 2

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Recommended Texts and Reference Books:

1. Buddy D. Ratner, et al, Biomaterials Science, Second Edition: An Introduction to Materials in Medicine
2. Handbook of Biomaterial Properties (*Second Edition) edited by William Murphy, Jonathan Black, Garth Hastings.*
3. Michael N. Helmus (Editor), Biomaterials in the Design and Reliability of Medical Devices
4. David Hill, Design Engineering of Biomaterials for Medical Devices
5. Jos Vander Sloten (Editor), Computer Technology in Biomaterials Science and Engineering (Biomaterials Science & Engineering)
6. Kay C. Dee, et al, An Introduction to Tissue-Biomaterial Interactions
7. Joon B. Park, Joseph D. Bronzino, Biomaterials Principles and Application
8. Xian, Wujing, A laboratory course in biomaterials, 2009.
9. Mahapatro, Anil, Polymers for biomedical applications, 2008.
10. Temenoff, J. S, Biomaterials: The intersection of biology & materials science, 2008.

Engineering Management

Contact Hours:
Theory =48
Practical = 00
Total = 48

Credit Hours:
Theory =3.0
Practical = 0.0
Total = 3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Explain** the fundamental engineering management principles	Cognitive	2	11
2.	**Describe** the knowledge and skills needed to effectively lead a team	Cognitive	2	1,9

3.	**Prepare** decision-making and management engineering methodology to analyze problem	Cognitive	3	2, 3
4.	**Evaluate** the importance of Total Quality Management	Cognitive	6	4

Course Outline

1. **Introduction to Engineering Management**
   a. Role of Engineer in Management;8
   b. Functions of Management
   c. Planning and Techniques of Management

2. **Organizational Management Engineering**
   a. Organizing Engineering and Structure
   b. Establishment of working relationship
   c. Market for engineering products
   d. Types of Markets

3. **Managerial Decision Making and Management of Operations**
   a. Efficient Managerial Decision in Healthcare setting
   b. Simulation Modeling of Healthcare delivery
   c. Simulation Applications in Healthcare setting
   d. Modeling clinical engineering activities to support healthcare technology management

4. **Management and Supervision**
   a. Principles of Hospital management
   b. Legal, Professional and Ethical Aspects
   c. Resources, duties and functions of medical and paramedical staff
   d. Planning, Knowledge of various Hospital services

5. **Cost and Quality Management**
   a. New Cost Accounting Model
   b. New Indicators for Hospital Management Based on Personnel Cost
   c. Total Quality Management

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Sessional (20%)
  Quiz (12%)
  Assignment (8%)
  Midterm (30%)
  Final Term (50%)

Recommended Books:

1. Buchbinder Sharon, Introduction to Healthcare Management Latest ed.
2. Alexander Kolker, Management Engineering for Effective Healthcare Delivery: Principles and Applications, 2012
3. Kaluzny, Warner, Warren, Zelman, Management of Health Services
4. Sakharkar Sharon B, Principles of Hospital Administration & Planning, 2009

Medical Imaging

Contact Hours:

Theory =32
Practical =48
Total =80

Credit Hours:

Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Describe** the fundamental concepts related to radiation physics involved in radiological equipment**.**	Cognitive	2	1
2.	**Explain** the principles and technological basis of radiological equipment such as X-ray radiography, fluoroscopy, MR Imaging, ultrasound imaging, nuclear medicine and x-ray computed tomography (CT).	Cognitive	2	1
3.	**Differentiate** between the different types of radiological diagnostic equipment such as MRI, X Ray, CT and Ultrasound	Cognitive	4	1,2
4	**Observe** the function of medical imaging equipment used for diagnostics.	Psychomotor	1	1

Course Outline:

1. **X-ray Imaging**
   a. Physics of X-ray
   b. Imaging with X-ray
   c. Radiation dose
   d. Attenuation based X-ray Imaging
   e. X-ray Detection
   f. X-ray Image Quality
   g. Diagnostic Applications of X-ray Imaging
   h. Demonstration of X-rays Equipment

2. **Principles of Computed Tomography**
    a. Introduction to Computed Tomography and Scanners
    a. Attenuation Tomography
    b. Time of Flight Tomography
    c. Reflection Tomography
    d. Diffraction Tomography
    e. Formulation of Attenuation Computed Tomography
    f. Fourier Slice theorem
3. **Magnetic Resonance Imaging**
    a. Physical and physiological principle of Magnetic Resonance Imaging
    b. MR Imaging
    c. Formulation of MRI reconstruction
    d. Functional MRI, BOLD MRI,
    e. Applications of MRI and fMRI
4. **Ultrasound Imaging**
    a. Generation and detection of ultrasound waves
    b. Physical and physiological principles of Ultrasound
    c. Resolution of Ultrasound imaging
    d. Ultrasound Imaging Modalities
    e. Doppler Ultrasound Imaging
    f. Modes of ultrasound image representation
    g. Ultrasound Image Artifacts
5. **Positron Emission Tomography**
    a. Physical and physiological principles of PET
    b. PET Signal Acquisition
    c. PET Image formation
    d. Significance of PET
    e. Applications of PET

List of Practicals:

1. Demonstration of X-rays Equipment
2. Demonstration of X-ray Tube components
3. Demonstration of the X-ray collimator, Grids, and Filters
4. Demonstration of Ultrasound Equipment and differentiate between contrast
5. Ultrasound of liver and Gallbladder
6. Ultrasound of spleen
7. Ultrasound of kidney
8. Ultrasound of pancreas
9. Visualization of MRI images
10. Demonstration of CT Scan images of the cerebral aneurysm
11. Demonstration of MRI images of the Brain Tumors and discuss the related issues
12. Demonstration of MRI images of the Knees and discuss the related issues

13. Demonstration of the fluoroscopic images of the blood flow through the arteries
14. Demonstration of the PET Scans
15. To understand the difference between PET and MRI and CT scan
16. Open ended lab 1

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. Bushberg J.T., The Essential Physics of Medical Imaging 3rd Ed.
2. Z. H. Cho, Foundations of Medical Imaging
3. Biomedical Imaging (Principles & Application Engg: Series).
4. Digital Image Processing for Medical Applications, Geoff Dougherty, Cambridge University Press 978-0-521-86085-7

Technical Report Writing

Contact Hours:

Theory =48
Practical =0
Total =48

Credit Hours:

Theory =3.0
Practical =0.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	Gain the ability to use modern presentation skills.	Cognitive	3	10
2.	Gain the ability to know basics of technical report writing.	Cognitive	3	10
3.	Have a skill to write correct technical English in proposal preparation, research papers and reports preparations.	Psychomotor	3	10

Course Outline:

1. **Presentation skills**
   a. Essay writing (Descriptive, narrative, discursive, argumentative)
2. **Academic writing**
3. **How to write a proposal for research paper/term paper**
4. **How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency)**
5. Technical Report writing
6. Progress report writing

List of Practicals:

- N.A

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)

Text and Reference Books:

1. Patterns of College Writing (4th Edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press
2. The Mercury Reader. A Custom Publication. Compiled by Norther Illinois University. General Editiors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharton.
3. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).
4. College Writing Skills by John Langan. McGraw-Hill Higher Education. 2004.

Professional Practices and Ethics

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0.0
Total	=48	Total	=3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** basic knowledge of Professional Practices and ethics in the domain of biomedical engineering	Cognitive	1	1&8
2.	**Acquire** knowledge about Relationship between Professional Practice and Engineering Management	Cognitive	1	1&8
3.	**Explain** the concepts of management, quality and planning as a biomedical engineer.	Cognitive	2	1&10
4.	**Apply** the understanding of Professional Practice to plan engineering projects.	Cognitive	3	1&11

Course Outline:

1. **Professional Practices**
   a. Overview of professional practices in Biomedical Engineering.
   b. Engineering management in biomedical engineering
   c. Relationship between Professional biomedical engineering Practice and Engineering Management
2. **Engineering Project Lifecycle**
   a. Definition of project
   b. Difference between engineering project and business process
   c. Skills set for a project manager
3. **Management**
   a. Need of managing engineering projects
   b. Scope of Management
   c. Resource and Cost Management
   d. Quality Management
   e. Risk Management
4. **Quality**
   a. Definition of Quality
   b. Quality Vs. Grade
   c. Quality Management Process
   d. Defining SLAs for an engineering project
   e. Performance Reporting
5. **Planning**
   a. Engineering Projects Planning
   b. Monitoring and Controlling
   c. Cost Estimates and Budget Constraints

6. **Professional Ethics**
    a. Ethical responsibilities of Biomedical Engineers and Moral Complexities.
    b. Health-Ethics
    c. WHO's Health Policies
    d. Codes of law of renowned societies for engineers
    e. Code of law of Biomedical engineering society
    f. Biomedical Engineers Pakistan code of ethics
    g. Ethical challenges for Biomedical Profession.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
    Sessional (20%)
        Quiz (12%)
        Assignment (8%)
    Midterm (30%)
    Final Term (50%)

Recommended Text and Reference Books:

1. Evans, J.R. & Lindsay, W.M., The Management and Control of Quality, 2011, 8th Edition, West Publishing, ISBN9780538452601.
2. White, M.A. and Bruton, G.D., The Management of Technology, 2006, Thomson South Western, ISBN: 0-234-3565-0
3. Meredith & Mantel, Project Management - A Managerial Approach, 2014, 9th Ed, Prentice Hall, ISBN: 978-1-118-94583-4.

Entrepreneurship

Contact Hours:	**Credit Hours:**
Theory =48	Theory = 3.0
Practical = 0	Practical = 0.0
Total = 48	Total = 3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1	To **demonstrate** entrepreneurial skills by discussing case studies.	Cognitive	3	6
2	To **make** sustainable business plans for a given case study.	Cognitive	3	7
3	To **demonstrate** team building for successful businesses by participating in a group project.	Affective	2	9
4	To **demonstrate** successful project management skills through participation in a given project.	Cognitive	3	11
5	To **apply** knowledge for critical review of contemporary problems, Innovation & Technology Development.	Cognitive	3	12

Course Outline:

1. **Course Overview and Introduction to Entrepreneurship**
   a. Entrepreneurship Jigsaw Puzzle.
   b. Intrapreneurship & Entrepreneurship
   c. Allocation of projects
2. **Nature & Development of Entrepreneurship**
   a. Types of Start-Ups
   b. Role of Entrepreneurship in Economic Development.
   c. Skill Requirements for Entrepreneurship
   d. Ethics & Social Responsibility of Entrepreneurs
   e. Future of Entrepreneurship.
3. **Identifying & evaluating the opportunity**
   a. Developing the Business Plan
   b. Determining the resources required for managing the Enterprise.
   c. Managerial Versus Entrepreneurial Decision Making
   d. Causes for Interest in Entrepreneurship
   e. Corporate Versus Intrapreneurial Culture
   f. Comparison of Entrepreneurial
   g. Intrapreneurial& Traditional Managers.
   h. Climate for Intrapreneurship
   i. Intrapreneurial Leadership Characteristics.
   j. Establishing Intrapreneurship in the Organization.
   k. Problems and Successful Efforts.
4. **The Individual Entrepreneur**
   a. Discuss basic criteria for evaluating business ideas

5. **Entrepreneurial Strategy**
    a. Entrepreneurial Feelings.
    b. Entrepreneurial Background and Characteristics.
    c. Motivation for Entrepreneurship.
    d. Role Models and Support Systems.
    e. Entrepreneurs versus Inventors.
    f. Non-Entrepreneurial Profiles
    g. Twenty Principles of Entrepreneurship
    h. Writing and Using the Business Plan.
    i. Planning for business operation.
    j. Guest Speaker Session.
6. **Product Development**
    a. Essentials of New Product Development.
    b. Examples of change in Product Design & Manufacturing
    c. Development processes & Organizations
    d. Guest Speaker Session.
    e. Identifying Customer Needs
    f. Establishing Product Specifications
    g. Sustainable Manufacturing
7. **Marketing, Organizational and Financial plan**
    a. Introduce basic marketing plans for entrepreneurial firms
    b. Examine basic organizational forms for entrepreneurial firms
8. **Entrepreneurial Financing:**
    a. Discuss financing issues for new ventures
    b. Introduce venture capital investment process
9. **Project Management Skills for Entrepreneurial projects**
10. **Project Presentations**

Suggested Teaching Methodology:

- Lecturing
- Guest lectures
- Project

Suggested Assessment:

- **Theory (100%)**
    Sessional (20%)
        Quiz (12%)
        Assignment (8%)
    Midterm (30%)
    Final Term (50%)

Text and Reference Books:

1. “Entrepreneurship (5th Edition), Robert D. Hisrich& Michael P. Peters. McGraw-Hill Irwin. Product Design & Development, Karl T Ulrich & Steven D. Eppinger.

2. Case studies and others will be placed with the photocopier and soft copies of presentations will be uploaded on LMS.
3. Technology Ventures (2013 Edition), Richard C. Dorf & Thomas H. Byers.

Biomedical Engineering Project

Contact Hours:
Theory =0.0
Practical =288
Total =288

Credit Hours:
Theory =0.0
Practical =6.0
Total =6.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**PLAN** the project activities to fulfill the proposed research problems	Cognitive	C4	6,8,10
2.	**MANAGE** the project plan to accomplish project objectives	Cognitive	C3	2,3,4,11
3.	**EXECUTE** the project plan	Psychomotor	P4	3,5,9
4.	**ANALYZE** project results using appropriate technique or tools	Cognitive	C4	2,7,12
5	**PRODUCE** a project report in accordance with specified standard format	Cognitive	C4	2,12
6	**PRESENT and DEFEND** the project outcomes effectively	Affective	A3	1, 9,10

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge:	☑	7	Environment and Sustainability:	☑
2	Problem Analysis:	☑	8	Ethics:	☑
3	Design/Development of Solutions:	☑	9	Individual and Team Work:	☑
4	Investigation:	☑	10	Communication:	☑
5	Modern Tool Usage:	☑	11	Project Management:	☑
6	The Engineer and Society:	☑	12	Lifelong Learning:	☑

Detail of Elective Courses

Bioelectricity

Contact Hours:

Theory =48
Practical =0
Total =48

Credit Hours:

Theory =3.0
Practical =0.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of bio electrical phenomena its application in Biomedical engineering	Cognitive	2	1
2.	**Understand** the concepts electrical Stimulation and its Application in Biomedical engineering.	Cognitive	2	1
2.	**Solve, Analyze** and **Evaluate** the electrical stimulation applied to the physiological System	Cognitive	4	2

Course Outline:

1. **Introduction and Excitation Models**
   a. The course will include the Impedance and Current Distribution,
   b. Electrical Principles of Nerve and Muscle Function,
   c. Excitation Models.
2. **Electrical Stimulation**
   a. Electrical Properties of the Heart
   b. Cardiac Sensitivity to Electrical Stimulation
   c. Sensory Responses to Electrical Stimulation
   d. Skeletal Muscle Response to Electrical Stimulation,
   e. Stimulation via Electric and Magnetic Fields,
   f. Deep Brain Stimulation
   g. Electroconvulsive therapy
3. **Application of Electrical Stimulation**
   a. TENS for pain management
   b. TENS equipment, techniques, and biophysical principles,
   c. Appropriate electrode sites and electrical characteristics for TENS,
   d. Mechanism of action of TENS
   e. The use of TENS for non-painful conditions
   f. Functional electrical Stimulation,
   g. Bio-signal control based electrical stimulation.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

Theory (100%)

Sessional (20%)

Quiz (12%)

Assignment (8%)

Midterm (30%)

Final Term (50%)

Text and Reference Books:

1. Applied Bioelectricity From Electrical Stimulation to Electropathology by Reilly, J. Patrick.
2. Transcutaneous Electrical Nerve Stimulation (TENS): Research to support clinical practice by Mark I. Johnson

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Power Electronics

Contact Hours:

Theory =32
Practical =48
Total =80

Credit Hours:

Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand,** and **explain** the modern semiconductor devices and their switching and protection methods	Cognitive	2	1
2.	**Describe** the operation of different power converter applications	Cognitive	2	1
3.	**Apply** the acquired knowledge to **solve** different power electronics circuits	Cognitive	3	2
4.	**Explain** power electronic applications motor drives, and **evaluate** suitable converter types of a given application	Cognitive	6	2
5.	**Observes** knowledge of power electronics trainer board and	Psychomotor	1	1,5

	thyristor based power controller electronic circuits			
6.	**Make the setup** for development of power electronic circuit such as controlled rectifier, inverter, dc chopper, cycloconverter and AC regulator and motor controlling using power electronic trainer board	Psychomotor	2	2,5
7.	**Develop** different types of power electronics circuit such as controlled rectifier, inverter, dc chopper, cycloconverter and AC regulator and motor controlling using discrete components	Psychomotor	7	3

Course Outline:

1. **Introduction to power electronics**
   a. History of power electronics
   b. Applications
   c. Power electronic devices
   d. Triggering devices
   e. Manufacturers datasheet
   f. Device protection
2. **Diode circuits and rectifiers**
   a. Diodes with RLC loads
   b. Freewheeling diodes
   c. Single phase rectifiers
   d. Poly phase rectifiers
3. **Thyristor commutation**
   a. Natural commutation
   b. Forced commutation
   c. Commutation circuit design
4. **Controlled rectifiers**
   a. Phase controlled converter operation
   b. Semi-converter
   c. Full converter
   d. Dual converter
   e. Series converters
   f. Power factor improvement
   g. Design converter circuits
   h. Effects of inductances
5. **Static switches**
   a. Single phase AC switches
   b. Polyphase AC switches

c. DC switches
d. Design of static switches

6. AC voltage controllers

a. Single phase controllers
b. Polyphase controllers
c. Transformer tap changers
d. Cycloconverters
e. Design of AC voltage controller circuits
f. Effects of inductances

7. DC choppers

a. Introduction
b. Step-down and step-up chopper operation
c. Switching mode regulators
d. Thyristor chopper circuits
e. Chopper circuit design

8. Inverters

a. Principles of operation
b. Single phase inverters
c. Polyphase inverters
d. Voltage control of inverters
e. Harmonic reductions

9. Cycloconverters

a. Single phase cycloconverter circuits
b. Three phase cycloconverter circuits

10. DC motor drive applications

11. Voltage source converters and control

12. Waveform analysis, harmonic minimization, PWM AC motor drives

13. Power electronic applications in power systems

List of Practicals:

1. To become familiar with user interface of Pspice
2. To understand and design a circuit of 1-phase half and full wave uncontrolled rectifier.
3. To understand and design a circuit of 1-phase half wave controlled rectifier (0 to 90 degree).
4. To understand and design a circuit of 1-phase half wave controlled rectifier (0 to 180 degree).
5. To understand and design a circuit of 1-phase full wave controlled rectifier.
6. To understand and design a circuit of 3-phase half wave uncontrolled rectifier.
7. To understand and design a circuit of 3-phase full wave uncontrolled rectifier.

8. To understand and design a circuit of 3-phase half wave controlled rectifier.
9. To understand and design a circuit of 3-phase full wave controlled rectifier.
10. To understand and design a circuit of a Buck converter.
11. To understand and design a circuit of a Boost converter.
12. To understand and design a circuit of a Buck- Boost converter.
13. To understand and design a circuit of Cuk Converter.
14. To understand and design a circuit of a Single Phase Full Bridge Inverter.
15. Open ended lab 1
16. Open ended lab 2

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. N. Mohan, T. M. Undeland, and W. P. Robbins, Power Electronics: Converters, Applications, and Design, Media Enhanced 3rd Edition, John Wiley & Sons, Inc., 2003.
2. M. H. Rashid, Power Electronics: Circuits, Devices, and Applications, 4th Edition, Prentice Hall, 2014.
3. M. D. Singh and K.B. Khanchandani, 'Power Electronics', Tata McGraw-Hills Publishing Company Limited, 2nd Edition, 2006.
4. Power Electronics--A First Course" Mohan, Wiley.
5. Vedam Subramaniam, 'Power Electronics', New Age International (P) Ltd Publishers, 2001.
6. Philip T. Krein, 'Elements of Power Electronics', Oxford University Press, 1st Edition, 2012.
7. V.R.Moorthi, 'Power Electronics-Devices, Circuits and Industrial Applications', Oxford University Press, 1st Edition, 2005.

Rehabilitation Engineering

Contact Hours:
Theory =32
Practical =48
Total =80

Credit Hours:
Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Explain** the domains of rehabilitation engineering.	Cognitive	2	1
2.	**Demonstrate** limb Prosthetic devices, orthotic devices, devices for visually impaired, and devices for hearing Impairment	Cognitive	3	1
3.	**Conduct** experiments for analysis of physiological parameter during electrical stimulation.	Psychomotor	4	2
4.	**Recognize** assistive devices for hearing and visually impaired population.	Psychomotor	1	1

Course Outline:

1. **Introduction**
   a. Introduction to rehabilitation engineering and assistive technology (AT)
   b. Domains of rehabilitation engineering
   c. Future of rehabilitation engineering
2. **Limb Prosthetic Devices**
   a. Classification of amputation
   b. Prosthetic prescription and fabrication
   c. Components of upper limb prosthesis
   d. Components of lower limb prosthesis
3. **Orthotic Devices**
   a. Introduction
   b. Biomechanical principles of orthoses
   c. Design consideration
   d. Spinal orthoses
   e. Limb orthoses
4. **Devices for Visually Impaired**
   a. Dimensions of visual impairment and their impact on task performance
   b. General purpose assistive technology solutions
   c. Task-specific assistive technologies
   d. Technology for reading
   e. Writing and graphic access

5. **Devices for Hearing Impairment**
    a. Types of hearing impairment
    b. Historical overview of HAT (Hearing assistance technology)
    c. Medical and surgical approaches to restoring hearing function
    d. Assistive listening devices solutions
    e. Environmental adaptations and universal designs
6. **Wheelchairs**
    a. Manual wheelchairs and electrical power wheelchairs with brief history
    b. User profiles
    c. Basic structural components
    d. Power and drive systems
    e. Control system
    f. Power assisted wheelchairs
    g. Multifunctional wheelchairs
    h. Wheelchair standards
7. **Neurorehabilitation**
    a. Functional Electrical Stimulation
    b. Transcutaneous Electrical Stimulation
    c. Brain Computer Interface
    d. Assessment methods for neurorehabilitation

List of Practicals:

1. Angle measurements using electronic goniometer in rest and walking state
2. Foot pressure measurement using force sensitive resistors (FSR)
3. Modeling and simulation of biomechanics arm using Autocad
4. Gait parameter analysis
5. EMG measurement during Functional electrical stimulation (FES)
6. Assessment of EMG before and after TENS
7. Design of brain computer interface using neurosky EEG device to detect subject's response
8. Control of peripheral devices such as using neurosky EEG device to switch ON/OFF home appliances
9. Demonstration of electrical power wheelchair
10. Demonstration of hearing aid.
11. Demonstration of visually impaired devices.
12. Open ended Lab 1
13. Open ended Lab 2
14. Open ended Lab 3
15. Open ended Lab 4
16. Open ended Lab 5

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Lab Assessment (100%)**

Text and Reference Books:

1. Rory A Cooper and Hisaichi Ohnabe, An Introduction to Rehabilitation Engineering, 2006, ISBN: 9780849372223
2. Pedro Encarnação and Albert Cook, Robotic Assistive Technologies: Principles and Practice, 2017, ISBN: 9781498745727
3. Marko B. Popović, Biomechanics and Robotics, 2013, ISBN: 9789814411370
4. Albert M. Cook and Janice Miller Polgar, Assistive Technologies: Principles and Practice, 4th Edition, ISBN: 9780323096317
5. Kevin Russell Henderson, Wheelchairs: Perceptions, Technology Advances and Barriers, 2016, ISBN: 9781536103908
6. Michelle M. Lusardi, Orthotics and Prosthetics in Rehabilitation, 3rd Edition, ISBN: 9781437719369

Medical Robotics

Contact Hours:
Theory = 32
Practical = 48
Total = 80

Credit Hours:
Theory = 2.0
Practical = 1.0
Total = 3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the fundamental Knowledge of robots	Cognitive	2	1
2.	**Solve** mathematically the position and orientation of objects and the relationship between robot joint coordinates and tool position	Cognitive	3	2
3.	**Outline** the current state, types, rolls of medical robots, advantages/disadvantages of various mechanisms, and difficulty in force sensing for them.	Cognitive	2	2

4.	**Differentiate** types and characteristics of actuators, control systems and operating interface of medical robots.	Cognitive	2	2
5.	**Recognize** different movements of kinematics	Psychomotor	1	1
6.	**Make** robotic arm with sensor actuation	Psychomotor	4	2

Course Outline:

1. **Fundamentals**
   a. What is a Robot?
   b. Classification of Robots.
   c. What is Robotics?
   d. History of Robotics.
   e. Advantages and Disadvantages of Robots.
   f. Robot Components.
   g. Robot Degrees of Freedom.
   h. Robot Joints.
   i. Robot Coordinates.
   j. Robot Reference Frames.
   k. Programming Modes.
   l. Robot Characteristics.
   m. Robot Workspace.
   n. Robot Languages.
   o. Robot Applications.
   p. Other Robots and Applications.
   q. Social Issues.
2. **Robot Kinematics**
   a. Position Analysis.
   b. Robots as Mechanisms.
   c. Matrix Representation.
   d. Homogeneous Transformation Matrices.
   e. Representation of Transformations.
   f. Inverse of Transformation Matrices.
   g. Forward and Inverse Kinematics of Robots.
   h. Denavit-Hartenberg Representation of Forward Kinematic Equations of Robots.
   i. The Inverse Kinematic Solution of Robots.
   j. Inverse Kinematic Programming of Robots.
   k. Degeneracy and Dexterity.
   l. The Fundamental Problem with the Denavit-Hartenberg Representation.
   m. Differential Motions and Velocities.
3. **Differential Relationships**
   a. Jacobian.
   b. Differential Motions of a Frame.
   c. Interpretation of the Differential Change.

d. Differential Changes between Frames.
e. Differential Motions of a Robot and Its Hand Frame.
f. Calculation of the Jacobian.
g. How to Relate the Jacobian and the Differential Operator.
h. Inverse Jacobian.
i. Design Project.
j. Dynamic Analysis and Forces.

4. **Lagrangian Mechanics**
   a. A Short Overview.
   b. Effective Moments of Inertia.
   c. Dynamic Equations for Multiple-Degree-of-Freedom Robots.
   d. Static Force Analysis of Robots.
   e. Transformation of Forces and Moments between Coordinate Frames.
   f. Design Project.
5. **Trajectory Planning**
   a. Path vs. Trajectory
   b. Joint Space vs. Cartesian-Space.
   c. Basics of Trajectory Planning.
   d. Joint space trajectory planning,
   e. Cartesian space trajectories.
6. **Application of Robotic in BME**
   a. Introduction to medical robotics
   b. Mechanisms for medical robots
   c. Sensing for medical robots
   d. Actuators for medical robots
   e. Controls for medical robots
   f. Interfaces for medical robots

List of Practicals:

1 Introduction to the Rhino
2 The Tower of Hanoi
3 Forward Kinematics
4 Inverse Kinematics
5 Image Processing
6 Camera Calibration
7 Object Centroids
8 Camera Calibration
9 Pick and Place
10 Grading
11 Tactile and force sensing
12 Proximity sensing
13 Medical robotics
14 Open ended lab 1
15 Open ended lab 2
16 Open ended lab 3

Suggested Teaching Methodology:

- Lecturing
- Written Assignments

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. Robotics: Everything You Need to Know About Robotics from Beginner to Expert, Peter Mckinnon (Paperback– January 28, 2016)
2. Robotics, Vision and Control: Fundamental Algorithms in MATLAB, 2011
3. Springer Handbook of Robotics, Siciliano, Bruno, Khatib, Oussama, 2008
4. Robotics Modelling, Planning and Control, Siciliano, B.,Sciavicco, L., Villani, L., Oriolo, 2009.
5. Medical Robotics: Minimally Invasive Surgery, Paula Gomes, ISBN:9780857097392, 2012
6. Medical Robotics, Schweikard, Achim, Ernst, Floris, 2015

Biofluid Mechanics and Bioheat Transfer

Contact Hours:

Theory =32
Practical =48
Total =80

Credit Hours:

Theory =2.0
Practical =1.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of Biofluid mechanics and Heat transfer	Cognitive	2	1
2.	**Solve** problem related with conservation laws and its application in micro and macro Circulation.	Cognitive	3	2
3.	**Analysis** of the cardiovascular System	Cognitive	4	2
4.	**Make a setup** to understand basic laws of fluid mechanic	Psychomotor	2	1
5.	**Demonstrate** the flow of Newtonian and Non-Newtonian fluids	Psychomotor	4	2

Course Outline:

1. **Fluid Mechanics Basics**
   a. Term and Definition
   b. Scope of fluid mechanics
   c. Scope of Bio fluid Mechanics
   d. Fundamental Fluid Mechanics Equations
   e. Fluid as a continuum
   f. Elemental Stress and Pressure
   g. Viscosity
   h. Fluid Motions
   i. Two Phase flows
   j. Fluid Structure interaction
   k. Introduction to Turbulent flow the relation the Relationship of Turbulence to Biological Systems.
2. **Conservation Laws**
   a. Fluid Statics Equations
   b. Buoyancy
   c. Conservation of Mass
   d. Conservation of Momentum
   e. Momentum Equation with Acceleration
   f. Laws of thermodynamics
   g. The Navier Stokes Equations
   h. Bernoulli Equations
3. **Macrocirculation and Microcirculation**
   a. Heart Valve Function
   b. Arterial and Venous System
   c. Pressure, Flow, and Resistance of blood flow system
   d. Windkessel Model for Blood Flow
   e. Flow separation at Bifurcations and at walls
   f. Flow through Tapering and Curved Channels
   g. Pulsatile Flow and Turbulence
   h. Local control of Blood flow
   i. Pressure Distribution Throughout the Microvascular system
   j. Velocity Distribution Throughout the Microvascular system
   k. Hematocrit/Fahraeus–Lindquist Effect/Fahraeus Effect
   l. Plug Flow in Capillaries
   m. Heart Valve Movement
   n. Heart Function analysis
4. **Biosystems Heat Transfer**
   a. Microscale Heat Transfer
   b. Bioheat transfer
   c. Application of Magnetic Field in Hyperthermia
   d. Application of Ultrasonic wave

List of Practicals:

1 Density measurement of an unknown fluid.

2 Viscosity measurement of a fluid.
3 Demonstration of pressure change using a Bell Jar.
4 Expansion of balloon under vacuum.
5 To Study The Effect Of Pressure On Boiling Points Of Liquid
6 Studying the formation of clouds using Atmospheric Properties Chamber.
7 Demonstration of Bernoulli's effect using Venturi Apparatus with air and water.
8 Calculating Mass Flow Rate, Voulumetric Flow Rate And Velocity Of Flow Using Venturi Apparatus And Flow Sensor.
9 Calculating Pulmonary Functions using Spirometer
10 Calculating Lung Volume Functions using Spirometer.
11 Study of Buoyant Force and Specific Heat of Different Materials.
12 Measurement of Blood Pressure Using Sphygmomanometer and Differential Pressure Sensor.
13 To Study the Flow of Fluids of different temperature and densities.
14 To model, measure and understand the complex density driven circulation associated with heat transfer through convection using Density Circulation Model.
15 Open ended lab 1
16 Open ended lab 2

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. Biofluid Mechanics, An Introduction to Fluid Mechanics, Macrocirculation, Microcirculaltion, David Rubenstein, 2nd Edition
2. Nano and Bio Heat Transfer and fluid flow, Majid ghassemi, 1st Edition, 2017.

Bioinformatics

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=00	Practical	=0.0
Total	=48	Total	=3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Discuss** fundamentals of GENOMICS AND TRANSCRIPTOMICS with respect to bioinformatics.	Cognitive	1	1
2.	**Describe** the structure, classification and functions of protein & DNA	Cognitive	2	2
3.	**Compare** protein sequences.	Cognitive	4	1
4.	**Carry Out** a search to retrieve DNA and Protein sequences	Cognitive	3	4&9

Course Outline:

1. **History and evolution of bioinformatics**
   a. Introduction to databases (Database types, Database formats, DNA databases, European Molecular Biology Laboratory (EMBL)
   b. Genomics
   c. Transcriptomics
   d. Computational proteomics
2. **Pairwise Sequence Alignment**
   a. Evolutionary Basis
   b. Sequence Homology versus Sequence Similarity
   c. Sequence Similarity versus Sequence Identity
3. **Database Similarity Searching**
   a. Unique Requirements of Database Searching
   b. Heuristic Database Searching
   c. Basic Local Alignment Search Tool (BLAST)
   d. FASTA
   e. Comparison of FASTA and BLAST
4. **GenBank and DNA Data base of Japan (DDBJ)**
   a. Protein information Resource (PIR) formats
   b. Protein Sequence (databases, SwissProt, UniProt, UniProtKB/TrEMBL)
   c. Structural databases (Protein Databank (PDB), Structural Classification of Proteins (SCOP) database, Class, Architecture, Topology, Homology (CATH) database)

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**

Sessional (20%)
Quiz (12%)
Assignment (8%)
Midterm (30%)
Final Term (50%)

Text and Reference Books:

1. Introduction to Bioinformatics, Arthur M. Lesk, 4th Edition, Oxford University Press, 2014, ISBN 0198724675, 9780198724674
2. Bioinformatics and Functional Genomics, Jonathan Pevsner, 2nd Edition, Wiley, 2009, ISBN 0470085851, 9780470085851.

Artificial Intelligence

Contact Hours:
Theory =32
Practical =48
Total = 80

Credit Hours:
Theory = 2.0
Practical = 1.0
Total = 3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of artificial intelligence with emphasize on search algorithms and the concept of AI agents.	Cognitive	2	1
2.	**Apply** various search algorithms such as uninformed, informed and heuristic.	Cognitive	3	2
3	**Describe** fundamentals of knowledge representation, inference and theorem proving.	Cognitive	2	1
4	**Demonstrate** simple knowledge-based systems.	Psychomotor	3	2,3

Course Outline:

1. **Introduction to Artificial Intelligence**
   a. Foundations of AI
   b. Agents and Environments.
   a. Structure of Agents.
   b. Problem Solving Agents.
2. **Problem Solving by Searching**
   a. Searching for Solutions.
   b. Uninformed Search Strategies
   c. Informed Search Strategies
   a. Informed (Heuristic) Search Strategies:

b. Greedy Best-first Search.
c. A* Search.
d. Heuristic Functions.

3. Reasoning and Knowledge Representation

a. Introduction to Reasoning and Knowledge Representation.
b. Propositional Logic.
c. First order Logic.
d. Reasoning with Uncertainty & Probabilistic Reasoning
e. Acting Under Uncertainty.
f. Bayes' Rule.

4. Learning

a. Decision Trees
b. ID3 Algorithm
c. Statistical Learning.

Lab Outline:

1. Introduction to AI related toolboxes in MATLAB
2. Generating and Processing Undirected and Directed Graphs Using MATLAB.
3. Developing AI agents in MATLAB
4. Develop small Agent networks in MATLAB
5. Breadth First Graph Search Algorithm Using MATLAB
6. Depth First Graph Search Algorithm Using MATLAB
7. A* Heuristic Search Algorithm Using MATLAB.
8. Greedy First Heuristic Search Algorithm Using MATLAB.
9. Min Max Constraint Satisfaction Problems Using MATLAB.
10. Implement of Propositional Logic in MATLAB.
11. Implementation of First order logic in MATLAB.
12. Reasoning with Uncertainty in MATLAB
13. Implementation of Probabilistic Reasoning in MATLAB
14. Implementation of Bayes' Rule in MATLAB
15. Decision Tree Algorithm for using MATLAB
16. Implementing ID3 Algorithm using MATLAB

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. Russell S.; Norvig P.; “Artificial intelligence – A Modern Approach”, Latest Edition, Prentice Hall.
2. Luger G.F.; Artificial Intelligence – Structures and Strategies for Complex Problem Solving”, Latest Edition, Pearson Higher Education.

Hospital Information Management Systems

Contact Hours:
Theory =48
Practical =00
Total =48

Credit Hours:
Theory = 3.0
Practical = 0.0
Total = 3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Describe** concepts, components and applications of Hospital Information System (HIS).	Cognitive	2	1
2.	**Discuss** latest developments in Hospital Management and Information Systems.	Cognitive	2	1
3	**Demonstrate** benefits of Electronic Health Records (EHRs) and use of Decision Support Systems (DSS) in HIS	Cognitive	3	3
4	**Outline** action plan to transform traditional hospital information systems to modern HIS with EHRs and DSS for improved efficiency.	Cognitive	4	6

Course Outline:

1. **Introduction**
   a. Basics of Information Systems
   b. Rudiments of Healthcare Information Management System
   c. HIS, Now and future
2. **Data standards, Handling and Processing**
   a. Data representation
   b. Storage Tiers
   c. Data Structure
   d. Flow Charts and Work Process Flow Diagrams
   e. Electronic Health Records (HERs)
   f. Pros & Cons of Paper medical records
   g. Functions and Benefits of EHRs

3. **Subsystems of HIS**
    a. Health Information Systems in Clinical Settings
    b. Laboratory Information Systems
    c. Radiology Information Systems
    d. Clinical Decision Support Systems (CDSS)
    e. Healthcare Financial Management.

4. **Network and Communication**
    a. Medical device networking
    b. DICOM
    c. HL7 standards

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
    Sessional (20%)
        Quiz (12%)
        Assignment (8%)
    Midterm (30%)
    Final Term (50%)

Text and Reference Books:

1. Strategic Information Management in Hospitals: An Introduction to Hospital by Reinhold Haux ISBN:0-378-40356-6
2. Medical Data Management: A Practical Guide ISBN 978-0-387-21773-4

Medical Device Quality Systems and Standards

Contact Hours:

Theory	=48
Practical	=0
Total	=48

Credit Hours:

Theory	=3.0
Practical	=0.0
Total	=3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of medical device quality system standard	Cognitive	2	1

Course Outline:

1. **Quality Management System**
    a. Term and Definition

b. General Requirements
c. Quality Manual
d. Control of Documents
e. Controls of Records

2. **Management Responsibility and Resource**
   a. Management commitment Requirement
   b. Planning
   c. Responsibility, Authority, and Communication.
   d. Provision of Resources
   e. Infrastructure and work environments
3. **Product Realization**
   a. Planning of Product Realization
   b. Customer Related Processes
   c. Design and Development
   d. Purchasing
   e. Production and Service Provision
   f. Validation of Processes of Production
   g. Identification and Traceability
   h. Control of Monitoring and Measuring Device

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)

Text and Reference Books:

1. A Complete Guide to Quality Management in the Medical Device Industry, ItayAbuhav

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Medical Image Processing

Contact Hours:		**Credit Hours:**	
Theory	=32	Theory	=2.0
Practical	=48	Practical	=1.0
Total	=80	Total	=3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the basic knowledge of fundamentals of Medical Image Processing techniques (spatial domain, frequency domain, noise removal, image reconstruction and image segmentation).	Cognitive	1	1
2.	**Analyze** the medical image to remove noise.	Cognitive	4	1
3.	**Practice different** filtration techniques on different medical images using software tools.	Psychomotor	3	2,5
4.	**Perform** the segmentation on different medical images using software tools.	Psychomotor	5	2,5

Course outline:

1. **Digital Image Fundamental**
   a. Image file formats
   b. Elements of Visual Perception
   c. Image Sampling and Quantization
   d. An Introduction to the Mathematical Tools Used in Digital Image Processing

2. **Intensity Transformations and Spatial Filtering**
   a. Basic Intensity Transformation Functions
   b. Histogram Processing
   c. Fundamentals of Spatial Filtering
   d. Smoothing Spatial Filters
   e. Sharpening Spatial Filters

3. **Filtering in the Frequency Domain**
   a. Review of Concept about Fourier in 1D
   b. Fourier Functions of Two Variable
   c. The Basics of Filtering in the Frequency Domain
   d. Image Smoothing Using Frequency Domain Filters
   e. Image Sharpening Using Frequency Domain Filters

4. **Image Restoration and Reconstruction**
   a. Noise Models
   b. Restoration in the Presence of Noise Only-Spatial Filtering
   c. Periodic Noise Reduction by Frequency Domain Filtering
   d. Inverse Filtering, Least Squares Filtering, GM filtering
   e. Image Reconstruction from Projections

5. **Image Segmentation**
    a. Point, Line, and Edge Detection
    b. Thresholding
    c. Region-Based Segmentation
    d. Segmentation Using Morphological Watersheds
    e. The Use of Motion in Segmentation
6. **Image Compression**
    a. Compression Standards
    b. Some Basic Compression Methods (Huffman Coding, Golomb Coding)

List of Practicals:

1 MATLAB: Introduction to MATLAB and image processing toolbox
2 Digital Image Fundamentals: Sampling and quantization, bits per pixel & shades, spatial resolution & image size, Zooming & shrinking images
3 Basic Gray Level transformations: Image Negative, Log transform.
4 Application Of Gamma Correction to enhance image
5 Contrast stretching and thresholding
6 Introduction to image Histogram , Histogram sliding
7 Histogram equalization
8 Enhancement using arithmetic/logic operations
9 Smoothing spatial filters (Mean and Median filters)
10 Sharpening spatial filters (Laplace and Sobel)
11 Un-sharp masking and high-boost filtering Combining Spatial Enhancement methods
12 Review of Fourier transform and convolution theorem, 2D-FT, FT and frequency components of an image
13 Lowpass and Highpass Filters: Ideal filters, Butterworth filters, Gaussian filters. Filters comparison, Unsharp Masking
14 Dilation and erosion
15 Detection of discontinuities, Edge linking and boundary detection, Segmentation by thresholding
16 Object recognition, classification and image compression

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
    Sessional (20%)
        Quiz (12%)
        Assignment (8%)
    Midterm (30%)
    Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. Digital Image Processing for Medical Applications by Geoff Dougherty, Cambridge University Press.
2. Digital Image Processing by Gonzales, R. C., Prentice Hall, New Jersey.

Telemedicine Systems

Contact Hours:
Theory =32
Practical = 48
Total = 80

Credit Hours:
Theory = 2.0
Practical = 1.0
Total = 3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Define** basics of Telemedicine Systems and applications	Cognitive	1	1
2.	**Identify** rudiments of a Telemedicine System.	Cognitive	2	1
3.	**Demonstrate** medical device networking by exploiting the concepts of IoT.	Cognitive	3	3
4.	**Understand** dependability of telemedicine solutions.	Cognitive	2	1
4.	**Prototype** design of a Telemedicine System using NI Simulator	Psychomotor	4	3

Course Outline:

1. **Origins and Development of Telemedicine**
   a. Overview of e-Health, Telehealth and Telemedicine
   b. Technological & non-technological drivers
   c. Benefits and limitations of telemedicine
   d. Telemedicine in developed & underdeveloped nations
2. **Technologies of Telemedicine Systems**
   a. Types of information & transmission
   b. Tele-Consultation and Telemonitoring
   c. Types of Wireless Networks
   d. Communication Protocols, shared variables and network streaming
3. **Telemedicine Applications**
   a. Tele-Radiology
   b. Tele-Dermatology
   c. Tele-Pathology
   d. Tele-cardiology

e. Tele-Ophthalmology
f. Tele-Surgery
g. Tele-psychiatry
h. Tele-dentistry
i. Disaster Management

4. **Development and Delivery of Telemedicine Services**
   a. The Strategic Context of Service Development: USA, Australia, the UK and Malaysia
   b. The Evaluation of Pilot Studies
5. **Ethical and Legal Aspects of Telemedicine**
   a. Confidentiality, Patient Rights and Consent
   b. Data Protection and Security
   c. Telemedical Malpractice
   d. Intellectual Property Rights
6. **Future Trends in Healthcare Technology**
   a. Prognostics in Telemedicine
   b. The Aging Population: Home Care for the Elderly
   c. Smart Home Assistive Technologies
   d. Clothing Technology and Healthcare
   e. Haptic Sensing for Practitioners

Lab Outline:

1. To examine the building blocks of LabVIEW application, including the front panel, block diagram, palettes, controls, and indicators
2. To introduce the National Instruments Telemedicine System, DAQ system and develop Virtual Instruments (VIs) in LabVIEW
3. To develop Data flow programming, Structure, Array, Clusters in LabVIEW
4. To acquire physiological data from biomedical sensors to run Vis
5. To apply advance analysis and measurements on acquired bio signals
6. To communicate with VIs across a network using UDP
7. To communicate with VIs across a network using TCP/IP
8. To observe live data streaming using network streams
9. To acquire and analyze electrocardiogram in VIs with Vernier Electrocardiogram Sensor
10. To acquire and analyze muscle activity and fatigue by using Vernier Hand dynamometer.
11. Open ended lab 1
12. Open ended lab 2
13. Open ended lab 3
14. Open ended lab 4
15. Open ended lab 5
16. Open ended lab 7

Suggested Teaching Methodology:

- Lecturing

- Tutorial
- Assignment
- Individual / Group Project

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Books Recommended:

1. Bernard Fong, ACM Fong, CK Li "Telemedicine Technology: Information Technologies in Medicine and Telehealth" 2011 ISBN: 978-0-470-74569-4
2. Norris A. C, "Essentials of Telemedicine & Telecare", 2001 ISBN: 0-471-53151-0
3. Marlene Maheu, Ace Allen, Pamela Whitten, "E-Health, Telehealth & Telemedicine": A guide to startup and success. ISBN: 0787944203
4. B.S Chowdhry & Faisal Abro, "Telemedicine Modernization & Expansion of Healthcare System". ISBN: 969-86-80-00-4

Biophysics

Contact Hours:		**Credit Hours:**	
Theory	=32	Theory	=2.0
Practical	=48	Practical	=1.0
Total	=80	Total	=3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the understanding of biophysics as an interdisciplinary research field.	Cognitive	1	1
2.	**Understand** the link between the structure and functions of biological system from molecular to system level	Cognitive	1	1
3.	**Understand** the fundamental Biophysical characteristics of the living matter	Cognitive	1	1
4.	**Apply** the understanding of Biophysics for the relationship of the membrane transport mechanisms and the electrical activity of the cell.	Cognitive	2	1

5.	**Understand** the relationship between membrane transport, cellular activity, and brain signals measured by magnetoencephalography and how they can give information at the system level of the human brain.	Cognitive	2	2
6.	**Perform** experiment to find maximum absorption of a molecule to determine molar extinction coefficient	Psychomotor	5	1&9
7.	**Imitate** the performance for phonatory function analyzer to determine frequency, Intensity and airflow of speech phonics	Psychomotor	3	1

Course Outline:

1. **Optics**
   a. Optics of Vision: Quantum Nature of Vision
   b. Visual Sensation
   c. Bipolar Cells and the generation of Contrast Coding,
   d. Visual Transduction
   e. Parallel processing
   f. Receptive fields
   g. Ocular dominance.
2. **Biophysics of Hearing**
   a. Ear
   b. Electrical activity of ear
   c. Information processing
   d. Coding of intensity information
   e. Impedance properties of ear
3. **Nervous system**
   a. Biophysics of Neural Spike
   b. Information theory and Memory
   c. Nervous system.
4. **Structural Biophysics**
   a. Conformational analysis of proteins /polysaccharides on the basis of potential energy calculations.
   b. Molecular modeling of nucleic acids.
5. **Membrane Biophysics**
   a. Mechanisms
   b. Simple Diffusion and Electrodiffusion
   c. Electrochemical Equilibrium
   d. Nonequillibrium Situations: Ion Fluxes, Passive Transport through Membranes
   e. Electrical Measurements
   f. dialysis equilibrium
   g. active ion transport

h. energetics of ion transport
i. estimation of membrane potential from equilibrium concentration

6. **Bioenergetics**
   a. Thermodynamic principles: First law (energy, enthalpy), Second law of Thermodynamics
   b. Free energy
   c. standard physical free energy
   d. standard biological free energy
   e. determination of the free energy from equilibrium constant and EMF measurements
   f. Thermodynamics of phosphate compounds (phosphate transfer reactions)
   g. Role of ATP for biological energy transfer
   h. Thermodynamics of life.
7. **Energy Pathways**
   a. Coupled Reactions
   b. Group Transfer Potential
   c. Role of Pyridine Nucleotides
   d. Energy Conversion Pathways
   e. Chemi-osmotic theory
8. **Muscle biophysics**
   a. Skeletal muscle structure
   b. muscle types
   c. muscle ultrastructure
   d. neuromuscular junction
   e. Excitation-Contraction coupling
   f. Skeletal muscle mechanics
   g. muscle energetics: heat production, energy metabolism
9. **Muscle energetics**
   a. phosphorylation of ADP by phosphocreatine
   b. anaerobic metabolism
   c. muscle diseases
10. **Respiratory Biophysics**
    a. Neurological control respiratory system
    b. Neural mechanisms
    c. chemical mechanisms
    d. Alternation of blood gases
    e. acid base balance
    f. buffer system
    g. lung diseases

List of Practicals:

1. Develop molecular model of Peptide Unit
2. Develop molecular model of Proteins
3. To find out the ionization constant of given acid (Acetic Acid) by pH titration curve

4. To find out the maximum absorption of Riboflavin by pectrophotometry and determination of molar extinction co-efficient
5. To calculate potential energy of biomolecules on the basic of non-bonded interactions
6. Potential energy determination on the basis of electrostatics Forces
7. Determination of free energy for Redox reactions in biological System
8. Determination of Redoxpotential for Cytochrome Fe^{++}
9. Demonstration of Sound and hearing (organ and pathway) by models and Computers
10. Tests of hearing and tests of vision
11. Demonstration of the taste and smell by models and Computers
12. To determine the standard curve of Riboflavin by Spectrophotometer
13. To locate the blind spot of the object by using Neurolab or similar software
14. Determination of frequency, Intensity and airflow of speech phonics using phonatory function analyzer
15. Demonstration of Ultrasound
16. To observe and analysis of the different types of errors and disease of Eyes by using the Neurolab software or similar software.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Recommended Books:

1. V. Pattabhi, N. Gautham, Biophysics, Kluwer Academic Publications.
2. Principles of Physical Biochemistry Book by K. E. Van Holde, Prentice-Hall International.
3. Physiology, Biophysics, and Biomedical Engineering (Series in Medical Physics and Biomedical Engineering), Andrew W Wood-CRC Press (2012)
4. Paul, Davidovitis, Physics in Biology & Medicine, 3rd Ed, 2007.

Cellular and Molecular Biology

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0.0
Total	=48	Total	=3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Develop** basic knowledge of cellular and molecular biology and **Describe** cellular genetics, biochemical, and developmental, physiological and pathophysiological aspects.	Cognitive	1	1
2.	**Understand** the relationship between cell structure and biochemical reactions.	Cognitive	1	1
3.	**Differentiate** between cell growth, survival and death.	Cognitive	1	1

Course Outline:

1. Basic properties of cells
2. Prokaryotic and eukaryotic cells
3. Viruses
4. Biological molecules: carbohydrates, lipids, proteins, and nucleic acids, Techniques used in cell and molecular biology
5. Enzymes
6. Metabolism
7. Mitochondrion structure and function
8. Chloroplast structure and function
9. Plasma membrane composition, structure, and function
10. The movement of substances across cell membranes
11. The endomembrane system
12. The extracellular matrix
13. The structure and function of the nucleus
14. Genes and chromosomes
15. DNA replication
16. Transcription, Translation
17. Cytoskeleton and cell motility
18. Cellular reproduction
19. Cell signalling

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)

Final Term (50%)

Reference Text Book:

1. H. Lodish et al. 2012. Molecular Cell Biology, 7th Ed. W.H Freeman and Company, and Turning
2. Molecular Biology of the Cell (MBC) 5th Edition, 2008 Alberts, Johnson, Lewis, Raff, Roberts, Walter.

DNA Computing

Contact Hours:

Theory =48
Practical =0
Total =48

Credit Hours:

Theory =3.0
Practical =0.0
Total =0.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** general understanding of computational methods for simulating biological macromolecules.	Cognitive	1	1
2.	**Describe** dynamics of DNA	Cognitive	2	1
3.	**Acquire** the knowledge of quantum in bioinformatics.	Cognitive	1	1
4.	**Analyze** biomolecules via computer simulations	Cognitive	4	2&5

Course Outline:

1. **Introduction to Biomolecules**
   a. Computational Biology : Introduction to Bioinformatics
   b. Protein folding and misfolding
   c. Protein Architecture: Sequence of amino acids
   d. protein interaction.
2. **Structures**
   a. Secondary structure of proteins
   b. Tertiary structure of proteins
   c. Nucleic Acid Structure.
3. **DNAs and RNAs**
   a. Interactions and conformations of DNAs.
   b. Interactions and conformations of RNA.
4. **Computer Simulations of biomolecules**
   a. Classical versus quantum descriptions
   b. Statistical mechanics of biomolecules (e.g., canonical ensemble, ergodicity)

c. Modeling interaction in protein (Bond-length and bond-angle potentials)
d. Molecular Dynamics Simulations

5. **Numerical integration of Newton equations of motion**
   a. Algorithms

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)
- **Laboratory (100%)**

Text and Reference Books:

1. D. Frankel and B. Smit "Understanding Molecular Simulations: From Algorithms to Applications"
2. T. E. Creighton "Proteins" (2nd edition, W.H. Freeman, and Co., New York)

Drug Delivery Systems

Contact Hours:

Theory =48
Practical =0
Total =48

Credit Hours:

Theory =3.0
Practical =0.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Explain** the Drug diffusion, drug dispersion, Drug Permeation, Drug Transport, Drug delivery systems	Cognitive	2	1
2.	**Explain** the ethical obligations applied in controlled drug delivery systems	Cognitive	2	8
3.	**Explain** different approaches for controlled drug delivery systems	Cognitive	2	1

Course Outline:

1. **Diffusion and Drug Dispersion**
   a. Equations for the diffusive flux (Fick's law)

b. Equations of mass conservation (Fick's second law)
c. Solutions to the diffusion equation with no solute elimination or generation
d. Solutions to the diffusion equation with solute binding and elimination
e. Applications

2. **Diffusion in Biological Systems**
   a. Measurement of diffusion coefficients
   b. Diffusion in water
   c. Diffusion in polymer solutions and gels
   d. Diffusion in the extracellular space
   e. Diffusion with binding in tissues
   f. Diffusion within cells
   g. Diffusion and reaction

3. **Drug Permeation through Biological Barriers**
   a. Mobility of lipids and proteins in the membrane
   b. Permeation through lipid membranes
   c. Permeation through porous membranes
   d. Permeation is enhanced by membrane proteins
   e. Permeation through cell layers

4. **Drug Transport by Fluid Motion**
   a. Blood movement in the circulatory system
   b. Interstitial fluid movement
   c. Fluid movement in the lymphatic circulation
   d. Fluid movement in the brain

5. **Drug Delivery Systems**
   a. Reservoir and transdermal delivery systems
   b. Matrix delivery systems
   c. Hydrogel delivery systems
   d. Degradable delivery systems
   e. Particulate delivery systems
   f. Responsive delivery system

6. **Case Studies in Drug Delivery**
   a. Controlled delivery of systemic therapy
   b. Implants for local drug delivery
   c. Topically applied devices for controlled release
   d. Ethical issues in Drug Delivery Systems

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Sessional (20%)

Quiz (12%)
Assignment (8%)
Midterm (30%)
Final Term (50%)

Text Book:

1. Drug Delivery: Engineering Principles for Drug Therapy by Saltzman; Oxford University Press.

Genetic Engineering

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0.0
Total	=48	Total	=3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Explain** the methodology of gene manipulation	Cognitive	2	1
2.	**Apply** the gene manipulation techniques Knowledge in Medical and forensic applications**.**	Cognitive	3	1
3.	**Analyze** the different PCR techniques	Cognitive	4	1

Course Outline:

1. **The basis of genetic engineering**
   a. The structure of DNA and RNA
   b. Gene organization
   c. Gene expression
   d. Genes and genomes
   e. Isolation of DNA and RNA
   f. DNA sequencing
   g. Restriction enzymes -- cutting DNA
   h. DNA modifying enzymes
   i. DNA ligase - joining DNA molecules
2. **The methodology of gene manipulation**
   a. Host cells and vectors
   b. Plasmid vectors
   c. Bacteriophage vectors
   d. Getting DNA into cells

3. **Cloning strategies**
    a. Cloning from mRNA
    b. Cloning from genomic DNA
    c. Advanced cloning strategies
4. **The polymerase chain reaction**
    a. The methodology of the PCR
    b. PCR techniques
    c. Processing of PCR products
5. **Medical and forensic applications of gene manipulation**
    a. Diagnosis and characterisation of medical conditions
    b. Treatment using rDNA technology -- gene therapy
    c. RNA interferenceing
    d. DNA profiling.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
    Sessional (20%)
        Quiz (12%)
        Assignment (8%)
    Midterm (30%)
    Final Term (50%)

Text and Reference Books:

1. An Introduction to Genetic Engineering, 3rd Edition. Desmond S. T. Nicholl, Cambridge University Press
2. Recombinant DNA: Genes and Genomes - A Short Course, 3rd Edition, Cold Spring Harbor Laboratory Press

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Neuroscience

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=00	Practical	= 0.0
Total	=48	Total	=0.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the understanding of mechanism involved in the transmission of information in the brain.	Cognitive	1	1
2.	**Describe** the modulation of brain function	Cognitive	1	1
3.	**Analyze** the role of neuro transmitters for various diseases.	Cognitive	4	2&4
4.	**Illustrate** the role of signaling pathways for their associated neurons	Cognitive	3	2&3

Course Outline:

1. **Introduction to neuroscience**
   a. Nervous system
   b. Sympathetic
   c. Parasympathetic and motor nervous system and their functions
   d. Brain and its functions
   e. Neurons and glia, structure of a neuronal cell, types of glia.
   f. Blood brain barriers.

2. **Neuronal Circuits**
   a. Neuronal circuit in emotional control
   b. Neuronal circuit in reward and addiction
   c. Neuronal regulation of stress

3. **Receptors**
   a. Ionotropic and metabotropic receptors
   b. signal transduction pathways
   c. G-proteins
   d. protein phosphorylation
   e. Signaling to the nucleus
   f. regulation of gene expression

4. **Neurotransmitters**
   a. Excitatory and inhibitory amino acid neurotransmitters
   b. Functions in the brain
   c. Pain pathways in brain
   d. Role of excitatory neurotransmitter in learning and memory
   e. Diseases associated with the malfunctioning of these neurotransmitters
   f. Neuronal degeneration

5. **Catecholamines**
   a. Functions in the brain

b. Diseases associated with the malfunctioning.

6. **Neural basis of behavioral plasticity**
   a. Human and animal memory
   b. Cellular mechanisms of neural plasticity
7. **Neuroendocrine and motivational systems**
   a. Endocrine systems
   b. Feeding behavior
   c. Stress
8. **Diseases of the nervous system**
   a. Addiction
   b. Depression
   c. Schizophrenia
   d. Epilepsy
   e. Alzheimer
   f. Parkinson
   g. Prion
   h. Motor Neuron Disease

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)

Recommended Books:

1. Progress in Neuroscience, Readings from Scientific American, John Wiley.
2. Philip, G. Srauge, Brain Biochemistry and Brain Disorders, Oxford Press.
3. George, J. Siegal, B. W. Agranoff, S. K. fisher , M. D. Uhler, Basic Neurochemistry: Molecular, Cellular and Medical Aspects, Lippincott D. Uhler.
4. Darakhshan Haleem, Neurochemistry, Neuropharmacology and Behavior, 2010.
5. Mark F. Bear, Barry W. Connors & Michael A. Paradiso, Neuroscience: Exploring the brain, 2006

Regenerative Medicine

Contact Hours:
Theory =48
Practical =0
Total =48

Credit Hours:
Theory =3.0
Practical =0.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** general understanding of mechanism of cell regeneration.	Cognitive	1	1
2.	**Explain** the basics of stem cells, cloning, therapeutic use of stem cells and tissue regeneration using hormones.	Cognitive	1	1
3.	**Understand** the concepts of tissue regeneration and apply the principles of tissue engineering and regenerative medicine to design an artificial organ in theory.	Cognitive	1	1
4.	Critically **Analyze** and **Evaluate** related research articles.	Cognitive	2	1 & 9

Course outline:

1. **Introduction to Regenerative medicine**
   a. Stem cell basics
   b. Mechanism of cell regeneration
2. **Therapeutic use of stem cells**
   a. Bioprinting
   b. Histology
   c. Gene therapy
   d. Cloning
3. **Nanomaterials for tissue regeneration**
   a. Nanoceramics
   b. Polymers
   c. "Smart" bioactive orthopedic implants
   d. Metals
4. **Case studies and article reviews**

Suggested Teaching Methodology:

- Lecturing

- Written Assignments
- Presentation
- Case Studies

Suggested Assessment:

- **Theory (100%)**
  - Sessional (20%)
    - Quiz (12%)
    - Assignment (8%)
  - Midterm (30%)
  - Final Term (50%)

Recommended Books:

1. Kay C. Dee, et al, An Introduction to Tissue-Biomaterial Interactions
2. Advances in Regenerative Medicine, Edited by Sabine Wislet-Gendebien, ISBN 978-953-307-732-1
3. Rolando Barbucci (Editor), Integrated Biomaterials Science
4. Temenoff, J. S, Biomaterials: The intersection of biology & materials science, 2008.
5. Tissue Regeneration - From Basic Biology to Clinical Application, Edited by Jamie Davies, ISBN 978-953-51-0387-5
6. Regenerative Medicine and Tissue Engineering - Cells and Biomaterials, Edited by Daniel Eberli, ISBN 978-953-307-663-8

Tissue Engineering

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0.0
Total	=48	Total	=3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** general understanding in the field of tissue engineering	Cognitive	1	1
2.	**Explain** the basics of tissue and biomaterial interaction.	Cognitive	1	1
3.	**Explain** the concepts of biocompatibility, biodegradable, bioreactor, cell culture, cell proliferation, extracellular matrix and growth factors.	Cognitive	2	1
4.	**Apply** the understanding of biomaterials and tissue engineering	Cognitive	3	2&3

	to**Design** a specific biological tissue with respect to its function, mechanical property and biocompatibility.			
5.	**Apply** the knowledge of biomaterials and tissue engineering to design a bioreactor for various tissues.	Cognitive	3	3, 9&12

Course outline:

1. **Introduction to Tissue Engineering**
   a. Fundamentals of Stem Cell Tissue Engineering
   b. Extracellular Matrix: Structure, Function, and Applications to Tissue Engineering
   c. Polymeric Scaffolds for Tissue Engineering Applications
   d. Nanocomposite Scaffolds for Tissue Engineering
2. **Tissue-Biomaterial interaction and response**
   a. Cell Adhesion
   b. Cell Migration
   c. Inflammatory and Immune Responses to Tissue Engineered Devices
3. **Tissue Engineering Applications**
   a. Bioengineering of Human Skin Substitutes
   b. Bone Tissue Engineering
   c. Cartilage Tissue Engineering
   d. Cardiac Tissue Engineering
   e. Muscle Tissue Engineering
5. Growth Factors
   a. Growth Factors and Morphogens: Signals for Tissue Engineering

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

- **Theory (100%)**
  Sessional (20%)
    Quiz (12%)
    Assignment (8%)
  Midterm (30%)
  Final Term (50%)

Recommended Books:

1. Buddy D. Ratner, et al, Biomaterials Science, Second Edition: An Introduction to Materials in Medicine
2. Handbook of Biomaterial Properties (*Second Edition) edited by William Murphy, Jonathan Black, Garth Hastings.*
3. David Hill, Design Engineering of Biomaterials for Medical Devices

4. Jos Vander Sloten (Editor), Computer Technology in Biomaterials Science and Engineering (Biomaterials Science & Engineering)
5. Kay C. Dee, et al, An Introduction to Tissue-Biomaterial Interactions
6. Temenoff, J. S, Biomaterials: The intersection of biology & materials science, 2008.
7. Tissue Regeneration - From Basic Biology to Clinical Application, Edited by Jamie Davies, ISBN 978-953-51-0387-5

Computational Fluid Dynamics

Contact Hours:
Theory =48
Practical =0
Total =48

Credit Hours:
Theory =3.0
Practical =0.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Ser	CLO	Domain	Taxonomy level	PLO
1.	**Understanding** of the theoretical basis of computational fluid dynamics	Cognitive	2	1
2.	**Demonstrate** CFD model for "real world" engineering	Cognitive	3	2
3.	**Analyze** complex problems using CFD	Cognitive	4	2
4.	**Develop** computational models and their results and to write a report conveying the result of the computational analysis	Cognitive	5	2,3

Course Outline:

1. **Biofluids, Blood Vessels and Respiratory System Walls**
   a. Introduction
   b. Blood Components
   c. Blood Plasma
   d. Blood Cells
   e. Blood Rheology
   f. Blood Constitutive Models
   g. Other Biofuids
   h. Blood Vessels
   i. Morphology
   j. Human Airway Walls

2. **Governing Equations**
   a. Introduction
   b. Incompressible Flow Equations
   c. Newtonian flow
   d. Inviscid Flow
   e. Boundary Layer Flow

f. Generalized Newtonian Fluids
g. Viscoelastic Fluids
h. Turbulence
i. Time averaging
j. Reynolds Averaged Navier-Stokes Equations (RANS)
k. Incompressible Solid
l. Small Strain Approximation
m. Viscoelastic Solids

3. Analytical Forms

a. Introduction
b. Steady Flow in Rigid Tubes
c. Unsteady Flow in Rigid Tubes
d. Unsteady Flow in Distensible Tubes

4. Computational Methods

a. Introduction
b. Spatial Discretization
c. Finite Difference Method (FDM)
d. Finite Volume Method (FVM)
e. Finite Element Method
f. Boundary Conditions
g. Temporal Discretization
h. Explicit Methods
i. Semi-implicit Methods
j. Fully- Implicit Methods
k. Some Numerical Algorithms
l. Convection and Convection-diffusion equations

5. Numerical Modelling of Wave Propagation

a. Introduction
b. One-Dimensional Equations
c. The Characteristic System
d. Boundary Conditions
e. Solution Methods
f. Global Taylor-Galerkin Method
g. Locally Conservative Taylor-Galerkin Method

6. Three Dimensional Problems

a. Introduction
b. Navier-Stokes Equations
c. Numerical Scheme
d. Cardiovascular Problems
e. Flow through a Carotid Bifurcation
f. Flow through a Human Aorta
g. Human Airways
h. A model human airway problem
i. Inhalation studies

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

Theory (100%)

Sessional (20%)

Quiz (12%)

Assignment (8%)

Midterm (30%)

Final Term (50%)

Text and Reference Books:

1. J.Y. Tu, G.H. Yeoh, and C. Liu, Computational Fluid Dynamics: A Practical Approach, 2nd Edition, 2012.
2. H.K. Versteeg and W. Malalasekera, An introduction to Computational Fluid Dynamics. The Finite Volume Method, 2nd Edition
3. J.D. Anderson, Computational Fluid Dynamics.
4. P.J. Roache, Fundamentals of Computational Fluid Dynamics.
5. P.J. Roache, Verification and Validation in Computational Science and Engineering.
6. J.C. Tannehill, D.A. Anderson and R.H. Pletcher, Computational Fluid Mechanics and Heat Transfer.
7. S.V. Patankar, Numerical Heat Transfer and Fluid Flow.
8. D.C. Wilcox, Turbulence modelling for CFD. All of the above textbooks can be found in the UNSW.

Nano-Biotechnology

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0.0
Total	=48	Total	=3.0

COURSE LEARNING OUTCOMES:

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

Sr. No.	CLO	Domain	Taxonomy level	PLO
1.	**Understand** the wide range of applications of nanotechnology and its interdisciplinary aspect. **Understand** principles governing the effect of size on material properties at the nanoscale, and perform quantitative analysis	Cognitive	2	1

2.	**Describe** how cells use these "soft machines" for generating energy, motion, synthesizing biomolecules	Cognitive	2	1
3.	**Acquire** a working knowledge in nanotechnology techniques	Cognitive	1	1
4.	**Correlate** the impact of nanotechnology and nanoscience in a global, economic, environmental, and societal context	Cognitive	4	2

Course Outline:

1. **The world of small dimensions**
   a. Nanoscale Properties (Electrical, Optical, Chemical)
2. **Nanoscale visualization techniques**
   a. Electron microscopy (TEM, SEM, Cryo-SEM)
   b. Scanning probe microscopy (AFM, STM)
   c. Diffraction techniques (XRD, synchrotron)
3. **Bionanomaterials**
   a. Biological building blocks
   b. Bionanostructures (nanofibers, nanotubes, nanocellulose)
4. **Biological nanomachines**
   a. Ribosomes,
   b. Photosynthesis systems,
   c. Bionanomotors
5. **Engineered Nanomaterials**
   a. Carbon nanomaterials (fullerenes, graphene, nanotubes, nanofibers)
   b. Metal nanoparticles (synthesis, properties and applications)
   c. Magnetic nanoparticles (synthesis, properties and applications)
   d. Quanatum dots, liquid crystals
   e. Nanoporous materials (metalic, zeolite, MOFs)
6. **Microfabrication methods** (photolithography, soft lithography, replication):
7. **Nanofabrication methods** (Top-Down approaches)
8. **Nanotechnology by self-assembly**:
   a. (Bottom-Up approach): Principles, thermodynamics, interactions, properties
   b. Supramolecular self assembly
   c. Protein nanotechnology
   d. DNA nanotechnology
9. **Microfluidics**
   a. Surface tension
   b. Capillarity
   c. Reynolds number

d. Diffusion,
e. Viscosity

10. Nanofluidics
a. Nanopores and nanocapillaries
b. Debye length

11. Diffusion in solid phase and drug delivery

12. Biological and medical microdevices
a. Lab on chips
b. Organ-on chips

13. Biosensors
a. Fabrication
b. Functionalization
c. Applications

14. Nanotechnology safety and the environment
15. Impact of nanotechnology on society and industry

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

Theory (100%)
Sessional (20%)
Quiz (12%)
Assignment (8%)
Midterm (30%)
Final Term (50%)

Text and Reference Books:

1. Brydson, R. M.; Hammond, C., Generic Methodologies for Nanotechnology: Classification and Fabrication. In Nanoscale Science and Technology, John Wiley & Sons, Ltd: 2005; pp 1-55.
2. Brydson, R. M.; Hammond, C., Generic Methodologies for Nanotechnology: Characterization. In Nanoscale Science and Technology, John Wiley & Sons, Ltd: 2005; pp 56-129.
3. Leggett, G. J.; Jones, R. A. L., Bionanotechnology. In Nanoscale Science and Technology, John Wiley & Sons, Ltd: 2005; pp 419-445.
4. Bucke, C., Bionanotechnology—lessons from nature. By David S Godsell. Wiley-Liss, Hoboken, NJ, 2004. 352 pp, ISBN 0 471 41719 X. Journal of Chemical Technology & Biotechnology 2005, 80 (8), 964-965.
5. Goodsell, D. S., In Bionanotechnology, John Wiley & Sons, Inc.: 2004; pp i-xii.
6. Gibbs, M. R. J., Nanomagnetic Materials and Devices. In Nanoscale Science and Technology, John Wiley & Sons, Ltd: 2005; pp 203-236.

7. Gerrard, J. A., Protein Nanotechnology: Protocols, Instrumentation, and Applications, Second Edition. Humana Press: Totowa, NJ, 2013.
8. Marie, R.; Kristensen, A., Nanofluidic devices towards single DNA molecule sequence mapping. Journal of Biophotonics 2012, 5 (8-9), 673-686.

Medical Devices Regulatory Affairs

Contact Hours:
Theory =48
Practical =0
Total =48

Credit Hours:
Theory =3.0
Practical =0.0
Total =3.0

COURSE LEARNING OUTCOMES:

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

Ser	CLO	Domain	Taxonomy level	PLO
1.	**Understand** major global reference regulations and harmonization efforts for medical devices, regulatory environment in key Asian markets for medical devices	Cognitive	2	1
2.	**Understand** general pre-market requirements, the legal logics behind the definition and regulation of advanced products	Cognitive	2	1

Course Outline:

1. **Introduction to regulatory affairs**
   a. The role of RA
   b. Introduction to major global reference regulations and harmonizations
   c. Overview of regulatory environment in major Asian reference countries
   d. Future trends in regulatory development
2. **Pre-market requirements**
   a. Background
   b. Classifications
   c. GMP
   d. Conformity assessment
3. **Advanced products**
   a. Combination products
4. **Medical Device Errors**
   a. Human Factors
   b. Electronic Health Records.
5. **Investigational Device Exemptions**
   a. HDEs

b. Medical Device 510(k)
c. Pre-Market Approval (PMA) submissions
d. **de novo** review and Product Development Protocol

6. FDA Enforcement

a. FDA Postmarket Transformation
b. Medicare Reimbursement
c. FDA and the Food and Drug laws.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing

Suggested Assessment:

Theory (100%)

Sessional (20%)
Quiz (12%)
Assignment (8%)
Midterm (30%)
Final Term (50%)

Text and Reference Books:

1. Medical Product Regulatory Affairs: Pharmaceuticals, Diagnostics, Medical Devices by John J. Tobin, Gary Walsh, ISBN: 978-3-527-31877-3
2. Handbook of Medical Device Regulatory Affairs in Asia by Jack Wong, Raymond Tong Kaiyu

SCHEME OF STUDIES
Master (2-Year) in Biomedical Engineering

Semester	Course Code	Subjects	Credits
First	BM-501	Core-I	3
	BS-501	Core-II	3
	BM 5XX	Core-III	3
		Total	**9**
Second	BM-5XX	Elective-I	3
	BM-5XX	Elective-II	3
	BM-5XX	Elective-III	3
		Total	**9**
Third	BM-6XX	Elective-IV	3
	BM-6XX	Elective-V	3
		Total	**6**
Fourth	BM-699	Master Thesis	6
		Total	**30**

The department may offer core/elective courses from the given list (but not limited to) according to the availability of resources.

Suggested List of Courses

BM 501 Systems Physiology
BM 502 Modeling & Simulation of Physiological Systems
BM 511 Research Methodology
BM 512 Biomedical Engineering Design
BM 611 Operations Management
BM 521 Advanced Digital Signal Processing
BM 522 Advanced Biomedical Signals & Systems
BM 621 Pattern Recognition
BM 531 Advanced Biomedical Instrumentation
BM 532 Embedded Systems & Applications
BM 533 Design of Medical Devices
BM 534 Medical Microsystems
BM-535 Biomedical Sensors
BM 542 Invasive and non-Invasive Brain Computer Interfaces
BM 543 Neuralengineering
BM 541 Advanced Rehabilitation Engineering
BM 551 Medical Informatics
BM 552 Biostatistics
BM 651 Telemedicine System
BM 661 Advanced Medical Image Processing
BM 662 Advanced Medical Imaging

BM 663 Ultrasonic Instrumentation and Imaging
BM 571 Advanced Biomaterials
BM 572 Biomaterials and Drug Delivery
BM 671 Advances in Tissue Engineering
BM 573 Cell and Molecular Biology
BM-581 Advanced Biomechanics
BM 681 Advanced Bio-Fluid Mechanics
BM-691 Selected Topics in Biomedical Engineering

DETAIL OF COURSES
FOR Master (2-Year)
IN BIOMEDICAL ENGINEERING

Modeling & Simulation of Physiological Systems

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0
Total	=48	Total	=3.0

Course Outline:

1. **Introduction**
   a. Model Human, an engineering point of view,
   b. Mathematical Model, types and variation of models.
2. **Cell Physiology and transport**
   a. Gibbs-donnan Equilibrium,
   b. Carrier Mediated Transport action potential,
   c. Energetics of Muscle Contraction.
3. **Motion**
   a. Electrical analogy of steady Flow,
   b. Newton law of viscosity, Laminar flow and Viscosity of Blood,
   c. General form of equation of motion,
   d. Sheer stress and endothelial cells.
4. **Signal Processing**
   a. Overview, signal acquisition and it's processing.
5. **Human Modeling**
   a. Techniques for Physiological system, Autoregressive modeling,
   b. Time frequency analysis,
   c. Physiology of autonomic nervous system and heart rate variability, Measurement of Physiological stress,
   d. Cardiac rhythm, EMG and Its spectral analysis and mean power frequency,
   e. EEG and Its spectral analysis & coherence.
   f. Modeling the respiratory System

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  - Sessional (30%)
    - Quiz (10%)
    - Assignment (10%)
    - Presentation (10%)
  - Midterm (20%)
  - Final Term (50%)

Text and Reference Books Recommended:

1. Donald R. Cooper, Pamela S. Chridler, Business Research Methods, Irwin McGraw Hill.
2. Arlene Finch, Conducting Research Literature Reviews, Sage Publications
3. John W. Creswell, Research Design: Quantitative & Qualitative Approaches, Sage Publications.

Research Methodology

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0
Total	=48	Total	=3.0

Course Outline:

1. **Introduction**
   a. Research and its characteristics
   b. Types of research
   c. Research process
2. **Research problem**
   a. Study population,
   b. Subject area,
   c. Considerations in selecting a research problem
   d. Defining and formulating a research problem
   e. Methodology
   f. Preparing the research design
   g. Conducting the research
   h. Examples of research at the university
3. **Literature review**
   a. Knowledge base
   b. Findings, and Contextualizing the findings

c. Clarity and focus of research problem
d. Finding and managing references

4. **Formulation of objectives**
   a. Characteristics of objectives
   b. Concepts, indicators and variables
   c. Identifying variables
   d. Types of measurement scales
   e. Constructing hypotheses, and functions of hypotheses
5. **Collecting data**
   a. Ethical issues in data collection
   b. Collecting information,
   c. Seeking consent
   d. Providing incentives
   e. Seeking sensitive information
   f. Possible harm to the participants
   g. Maintaining confidentiality
6. **Processing and analyzing data**
   a. Editing, classifying, and tabulating data
   b. Metadata
   c. Qualitative and quantitative data analysis
   d. Analysis of variance
   e. Hypothesis testing
   f. Kruskal-Wallis test
   g. Manual data analysis
   h. Computer tools for data analysis
7. **Report writing**
   a. Writing a research proposal
   b. Writing a project report
   c. Writing a thesis
   d. Writing a research paper
   e. Referencing
   f. Software for referencing
8. **Laboratory Exercises**
   a. Data analysis tool (SPSS/PASW/ANOVA etc.)
   b. Reference Manager (EndNote, JabRef etc.)
   c. Online tools (bibMe, and EasyBib),
   d. Search tools
   e. Professional writing tools (LATEX, LyX, etc)

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  - Sessional (30%)
    - Quiz (10%)
    - Assignment (10%)
    - Presentation (10%)
  - Midterm (20%)
  - Final Term (50%)

Recommended Books:

1. Research Methodology, P. Sam Daniel, 2011, ISBN: 978-81-7835-900-7
2. Practical Research Methods, Catherine Dawson, 2002, New Delhi, UBS Publishers' Distributors
3. Research Methodology - Methods and Techniques, C. R. Kothari, 1985, New Delhi, Wiley Eastern Limited, ISBN:
4. Research Methodology-A Step-by-Step Guide for beginners, 2nd Ed., Ranjit Kumar, 2005, Singapore, Pearson Education, ISBN:
5. Fundamentals of Research Methodology and Statistics, Yogesh Kumar Singh, 2006, ISBN : 978-81-224-2418-8

Advanced Biomedical Signals and Systems

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0
Total	=48	Total	=3.0

Course Outline:

1. **Introduction**
   a. Origins of biomedical signals, challenges in acquisition and interpretation, time and frequency domain representation,
   b. Filter Design and applications,

2. **Random Signals**
   a. Random signals and stochastic processes,
   b. Parametric and nonparametric estimation of power spectral density; case studies.

3. **Instrumentation**
   a. Signal acquisition, analysis and interpretation in a hospital, diagnostic laboratory.
   b. Time-frequency and time-scale analysis of biomedical signals, case studies.
   c. Adaptive processing of biomedical signals and applications.
   d. Emerging techniques in medical signal processing.
   e. Case studies: EEG/EMG and evoked potentials.

Suggested Teaching Methodology:

- Lecturing

- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  - Sessional (30%)
    - Quiz (10%)
    - Assignment (10%)
    - Presentation (10%)
  - Midterm (20%)
  - Final Term (50%)

Text and Reference Books Recommended:

1. Joseph, D. Bronzino, Medical Devices and Systems, 3rd Ed. 2006.

Biomedical Engineering Design

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0
Total	=48	Total	=3.0

Course Outline:

1. **Introduction**
   a. Principles of Electronic Instrumentation,
   b. Biopotential measurements,
   c. Electrical and Electronic device design for Biomedical Engineering,
   d. Laboratory experience designing devices for taking measurements of living systems.

2. **Analysis & Design**
   a. Principles, Skeletal and Cardiovascular implant Design;
   b. Selection of material, Stress and Functional Analysis, Failure Criteria, Fatigue Analysis, and Optimal Design;
   c. Case studies, Computer aided design methods, design of subsystems.

3. **Tools**
   a. Computational methods and tools in Design and Analysis,
   b. 3-D Modeling and Simulation, Systematic approach for Creation of Virtual 3-D models (digital prototypes),
   c. Visualization and Physical Simulation, Matrix transformations, Geometric modeling,
   d. Design of artificial organs and prostheses.

4. **Product Development**
   a. Product development for solving Biomedical, Biotechnological, and Ergonomic problems.
   b. Teamwork in design,

c. Establishing Customer Needs, Writing Specifications, Legal and Financial Issues.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  - Sessional (30%)
    - Quiz (10%)
    - Assignment (10%)
    - Presentation (10%)
  - Midterm (20%)
  - Final Term (50%)

Recommended Books:

1. Biomedical Engineering & Design Handbook, Volumes I and II by Myer Kutz
2. Medical Instrument Design and Development: From Requirements to Market Placements
3. Claudio Becchetti, Alessandro Neri, ISBN: 978-1-119-95240-4
4. Design of Biomedical Devices and Systems, Third Edition, Paul H. King, Richard C. Fries, Arthur T. Johnson, July 29, 2014, ISBN 9781466569133 - CAT# K16421

Design of Medical Devices

Contact Hours:	
Theory	=48
Practical	=0
Total	=48

Credit Hours:	
Theory	=3.0
Practical	=0
Total	=3.0

Course Outline:

1. Introduction

a. What is Design?
b. The design life cycle.
c. Medical devices definitions

2. Classifying Medical Devices

a. Classification Rules
b. Classification Case study
c. Classification Models
d. Classification and the Design process

3. The Design Process

a. Design Process versus Design Control
b. Design Models

c. Managing Design
d. Cross Reference with Regulatory Requirements

4. Implementing Design Procedures
a. Audit/Review Procedure
b. The Design Process
c. Implementing a Procedure

5. **Developing Your Product Design Specification**
a. Developing the Statement of Need
b. The Product Design Specification
c. Finding, Extracting and Analyzing the Content

6. Generating Ideas and Concepts
a. Creative Space
b. Generating Concepts/Ideas
c. Selecting Concepts and Ideas

7. Quality in Design
a. Optimization
b. Design of Experiments
c. House of Quality
d. Failure Mode and Effect Analysis
e. D4X
f. Six Sigma

8. Design Realization/Detailed Design
a. The process to Design Realization
b. Assemble Your Detailed Design Team
c. Design Calculations
d. Materials Selection
e. Computer Aided Design

9. Evaluation
a. Risk Analysis
b. Criteria Based Evaluation
c. Computer Based Evaluation
d. Value to Healthcare Analysis
e. Clinical Studies and Clinical Trials

10. Manufacturing Supply Chain
a. Identifying Potential Suppliers
b. Packaging
c. Procurement

11. Labeling and Instructions for Use

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  - Sessional (30%)
    - Quiz (10%)
    - Assignment (10%)
    - Presentation (10%)
  - Midterm (20%)
  - Final Term (50%)

Recommended Books:

1. Medical Device Design: Innovation from Concept to Market 1st Edition by Peter J Ogrodnik(Author)
2. Handbook of Medical Device Design Edited by Richard C. Fries
3. Reiliable Design of Medical Device, 3rd Edition, by Richard C. Fries
4. Medical Device Design for SIX SIGMA by Basem S. EL Haik

Embedded Systems & Applications

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0
Total	=48	Total	=3.0

Course Outline:

1. **Embedded systems Fundamentals**
   a. Introduction to embedded systems
   b. Overview of the design flow
   c. Embedded system specification and modeling
   d. Embedded hardware platforms and peripherals
   e. Interfacing to the external world through sensors and actuators
   f. Design and synthesis of ASIC hardware
   g. Software organization, scheduling, and execution
   h. Fundamentals of real time and embedded systems.
   i. Real time operating systems.
   j. Wired communication and bus protocols
   k. Basics of wireless communication and embedded networking
   l. Energy management and low-power design
2. **Embedded System Processors**
   a. Microcontrollers
   b. Low-power microprocessors
   c. Digital signal processors and Field Programmable Gate Arrays (FPGA).
3. **Communication protocols**
   a. Overview of the Controller Area Network (CAN)
   b. Time-Triggered Protocol (TTP)
   c. Wireless networks used in wireless sensor networks;

d. Defining interfaces and the use of mixed-signal systems (digital and analog)

4. **Design and Development**
   a. Design methodologies.
   b. Safety and reliability in embedded systems design
   c. Secure embedded system design
   d. Development, debugging tools and programming languages. Reliability.

5. **Case Studies**
   a) Case studies: Low-end systems (medical devices, smart cards, sensors)
   b) Case studies: High-end systems (automobiles, home electronics, robotics)

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  - Sessional (30%)
    - Quiz (10%)
    - Assignment (10%)
    - Presentation (10%)
  - Midterm (20%)
  - Final Term (50%)

Text and Reference Books Recommended:

1. Barry. B. Brey, Embedded Controller: 80186, 80288 and 80386 Ex 1st Ed.
2. Designing Embedded Systems with PIC Microcontrollers, 2nd Edition, Principles and Applications, **Authors:** Tim Wilmshurst, **eBook ISBN:**9780080961842, **Paperback ISBN:** 9781856177504

Medical Microsystems

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0
Total	=48	Total	=3.0

Course Outline:

1. **Fabrication**
   a. Fundamental and advanced fabrication process for integrating materials into microstructures and micro devices.
   b. Micro patterning, moulding, sensing, and actuation technologies.

2. **Applications**
   a. Research concepts and applications of Microsystems at the molecular and cellular level.
   b. Applications such as DNA micro-arrays, drug and gene delivery, micro-sensors, actuators for research, microstructures for implants and micro-devices for prostheses.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  - Sessional (30%)
    - Quiz (10%)
    - Assignment (10%)
    - Presentation (10%)
  - Midterm (20%)
  - Final Term (50%)

Recommended Books:

1. Microsystems for Enhanced Control of Cell Behavior: Fundamentals, Design and Manufacturing Strategies, Applications and Challenges by Andrés Díaz Lantada, 2016
2. Biomechanical Microsystems: Design, Processing and Applications, By Vytautas Ostasevicius, Giedrius Janusas, Arvydas Palevicius, Rimvydas Gaidys, Vytautas Jurenas

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BM 541:
Rehabilitation Engineering

Objective:

This course is an introduction to a field of engineering dedicated to improving the lives of people with disabilities. Rehabilitation engineering is the application of engineering analysis and design expertise to overcome disabilities and improve quality of life. A range of disabilities and assistive technologies will be investigated. Describe in detail various types of physical and sensory disabilities of a temporary and permanent nature and be familiar with the devices and technology used to diagnose and improve such disabilities.

Course Outcomes:

The students will be able to demonstrate the numerical models to represent the musculoskeletal system and apply these models to the development of prosthetics/orthotics used in rehabilitation engineering. They will also be describe the fundamental principles and design considerations of medical

instruments currently in use for rehabilitation, e.g. EMG, EEG recording techniques and physiotherapy for rehabilitation purposes, back braces, wheelchairs etc.

Text books

1. **Rehabilitation Engineering Applied to Mobility and Manipulation**, Cooper RA.: 1995, Institute of Physics,
2. **Intelligent Systems and Technology in Rehabilitation Engineering**, Teodorescu H-NL & Jain LC.: 2001, The CRC International Series on Computational Intelligence,
3. **An Introduction to Rehabilitation Engineering**, R.A. Cooper, JH. Ohnanbe, D.A. Hobson: 2006, 9. Taylor & Francis

Detailed Course Contents:

Topics	Periods
Clinical Rehabilitation Science & Engineering: Principles, Terminology & Models Rehabilitative science foundations: healing biodynamics at the cell-tissue-organ-person levels, and understanding effects of interventions Existing infrastructure for the field of clinical rehabilitation and physical medicine. Clinical rehab engineering and the Human Activity / Assistive Technology (HAAT) model Sensorimotor Systems and Human Performance Assessment Conceptual Models of Human Performance and Interface Design Terminology and approaches in rehabilitation and ergonomics Basics of sensorimotor control (feedback, feedforward) Components of Sensory Performance and Relation to Technology Vision, gaze and video codes, resolution and sampling Hearing, speaking and audio codecs, frequency content, volume Reflexes, spasticity, positioning and measurement sampling Arms, reaching, tracking and robotic manipulators Hands, grasping, manipulation and computer interface devices Human-computer interface analysis (e.g., augmentative communication) Access Engineering: Accessible Interfaces and Telerehabilitation Telehealth conceptual model (science of rehab bioprocess, human-technology interfaces, behavior/compliance) Optimization modeling framework Telehealth Technologies Other technologies (e.g., vitals, activity monitoring, exercise)	45

Challenges of compliance, access to information/services; roles for tele-assessment Rehab Biomechanics of Devices and Interfaces Brief overview of biomechanics behind mobility and manipulation technologies Statics, solids, materials, kinematics, dynamics Principles of bi-causal mechanical interfaces Seated mobility devices Wheelchair considerations Seating considerations Positioning considerations Rehab Upper/Lower Limb amputations Devices and Interfaces Device assisting manipulation tasks Concept of Extended Physiological Proprioception (EPP) Upper extremity prosthetics: body-powered Upper extremity prosthetics: externally-powered Upper extremity orthotics Therapeutic and assistive robotics Neurorehabilitation: Innovation in Therapeutic Strategies Model of Rehabilitation Plan of Care (e.g., Neurorehab from Traumatic Event) Conceptual framework: diagnosis, prognosis, intervention, assessment, outcomes "Systems" analysis of this framework, as an optimization problem Mathematical model using fuzzy inference systems Conventional Approaches to Diagnosis, Intervention and Outcomes Assessment Classification: Assessment, intervention/therapy, activity monitoring (e.g., wearable) Interventions: Constraint-Induced Movement Therapy, rehab robotics, computer-assisted motivating therapy	

Cell & Molecular Biology

Contact Hours:

Theory	=48
Practical	=0
Total	=48

Credit Hours:

Theory	=3.0
Practical	=0
Total	=3.0

Course Outline:

1. **The Study of Cell Biology**
   a. Introduction to Cell Biology
   b. The Chemical Basis of Life
   c. Techniques in Cell and Molecular Biology

2. **Energy**
    a. Enzymes and Metabolism
    b. Mitochondrion and Aerobic Respiration
    c. Chloroplasts and Photosynthesis
3. **Membranes**
    a. Plasma Membrane
    b. Cytoplasmic Membrane Systems
    c. Cells and Their Environment
4. **Genetic Information**
    a. Gene and Genome
    b. Expression of Genetic Information
5. **Cytoskeleton, Cell Signaling, Cell Cycle, Cancer**
    a. Cytoskeleton and Cell Motility
    b. Cellular Reproduction
    c. Cell Signaling and Cancer

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
    - Sessional (30%)
        - Quiz (10%)
        - Assignment (10%)
        - Presentation (10%)
    - Midterm (20%)
    - Final Term (50%)

Recommended Books:

1. Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Amon A and Scott MP, 2012, Molecular Cell Biology, 7th edition. New York: W. H. Freeman and Company
2. Iwasa, J., & Marshall, W. *Karp's cell and molecular biology: Concepts and Experiments*. (8th ed.) (LOOSELEAF Format-Binder Ready Version). Hoboken, NJ: John Wiley & Sons, 2016.Type: Textbook: ISBN: 978-1-118-88614-4

Medical Informatics

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0
Total	=48	Total	=3.0

Course Outline:

1. **Introduction**
   a. History of Patient Record, Introduction to Computer Based Patient Record (CPR),
   b. Data from Patients, Coding and Classification,
   c. Strategies for Data Entry, Representation of Time and Clinical Use of the CPR, Clinical Departmental and Support Systems.

2. **Hospital Information System (HIS)**
   a. Scope of Hospital Information System (HIS),
   b. Challenges for the Health Care Sector, State of Transition, Objectives and Requirements,
   c. Planning, Modeling, Development, Architecture and Clinical Uses of HIS.
   d. Decision Support Models, Medical Reasoning, Quantitative & Qualitative Methods, Performance & steps involved,
   e. Uncertainty in Medical Judgment, Probability Theory and Decision Analysis.
   f. Characteristics & Implementing of Decision Support Systems.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  Sessional (30%)
    Quiz (10%)
    Assignment (10%)
    Presentation (10%)
  Midterm (20%)
  Final Term (50%)

Recommended Books:

1. Medical Informatics: Computer Applications in Health Care and Biomedicine Edward Hance Shortliffe, Leslie E. Perreault, Springer, 2001
2. Methods in Medical Informatics: Fundamentals of Healthcare Programming in Perl, Python and Ruby, By Jules J. Berman

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Telemedicine System

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0
Total	=48	Total	=3.0

Course Outline:

1. **Introduction**
   a. Introduction & Benefits of telemedicine.

2. **Communication technologies in telemedicine**
   a. Communication infrastructure-LAN and WAN technology.
   b. Satellite, Mobile, Internet technology for telemedicine.
   c. Video and audio conferencing.
   d. Medical information storage and management for telemedicine, patient information, medical history, test reports, medical images, diagnosis and treatment.
   e. Hospital information systems, Doctors, paramedics, facilities.
   f. Pharmaceutical, Security and confidentially of medical records and access control.
   g. Cyber laws, Access to health Care Services, Health Education and Self Care.
   h. Bio-modeling, medical data coding and compression, Functions of DICOM, PACS and HIS for Telemedicine.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  Sessional (30%)
  Quiz (10%)
  Assignment (10%)
  Presentation (10%)
  Midterm (20%)
  Final Term (50%)

Recommended Books:

1. Telemedicine: A Guide to Assessing Telecommunications for Health Care, edited by Marilyn J. Field
2. Handbook of Telemedicine, edited by Olga Ferrer-Roca, Marcelo C. Sosa-Iudicissa
3. Telemedicine and Telehealth: Principles, Policies, Performances and Pitfalls, By Adam William Darkins, Margaret Ann Cary

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Advanced Bio-Fluid Mechanics

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0
Total	=48	Total	=3.0

Course Outline:

1. **Introduction**
   a. Hemodynamic Theories of Atherogenesis,
   b. Womersley models, Steady and unsteady Flows in Curvature,
   c. Bifurcation and Branching Arterial Segments, Flow Dynamics, Past Prosthetic Implants.

2. **Modeling and Simulation**
   a. Experimental and Computational Models,
   b. Particulate and Mass Transport Simulations in Human Circulation.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  Sessional (30%)
    Quiz (10%)
    Assignment (10%)
    Presentation (10%)
  Midterm (20%)
  Final Term (50%)

Recommended Books:

1. Biofluid Mechanics by Jagannath Mazumdar
2. Biofluid Mechanics: An Introduction to Fluid Mechanics, Macrocirculation and Microcirculation, by David A. Rubenstein, Mary D. Frame, Wei Yin
3. Biofluid Dynamics: Principles and Selected Applications, by Clement Kleinstreuer
4. Advanced Fluid Mechanics, by William Graeb

Advanced Medical Imaging

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0
Total	=48	Total	=3.0

Course Outline:

1. **Image processing techniques**
   a. Algorithms for Processing and Analyzing Large Volumetric Data-Sets;
   b. Process of CT, MRI, Ultrasound; SPECT, etc.
   c. 3-D convolution and filtering, geometric transformations, shape features, surface segmentation, regional segmentation, surface tiling, surface reconstruction, volumetric registration.

d. 3-D Rendering, Image Integration & Tagging.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment

- **Theory (100%)**
  - Sessional (30%)
    - Quiz (10%)
    - Assignment (10%)
    - Presentation (10%)
  - Midterm (20%)
  - Final Term (50%)

Recommended Books:

1. Principles and Advanced Methods in Medical Imaging and Image Analysis, by Atam P. Dhawan, H. K. Huang, Dae-Shik Kim
2. Fundamentals of Medical Imaging, by Paul Suetens
3. Medical Imaging: Essentials for Physicians, by Anthony B. Wolbarst, Patrizio Capasso, Andrew R. Wyant

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Pattern Recognition

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0
Total	=48	Total	=3.0

Course Outline:

1. Techniques of pattern recognition

a. Theoretical foundations of classification and pattern recognition.
b. Applications in Object, Speech, Texture Recognition, Biomedical Patterns.
c. Image sensing and measuring objects, features and patterns.
d. Data acquisition, preprocessing, invariants, and representation issues.
e. Feature Reduction, Classification. Classifier complexity, bias variance, local and global error, error estimations, rejects, ROC.
f. Bayesian approaches, Discriminant Functions for Normal Class Distributions,
g. Parameter Estimation, Non-parametric Techniques (nearest neighbor rules, Parzen kernel rules, tree classifiers), Linear Discriminant Functions.
h. Supervised learning (Perceptron, LMS algorithms, support vector machines, Back propagation), unsupervised learning and clustering, Neural networks, Combining Classifiers.
i. Support Vector Machines, Hidden Markov Models.

j. Applications of Pattern Recognition to Gene patterns and Biomedical problems.

Suggested Teaching Methodology

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  - Sessional (30%)
    - Quiz (10%)
    - Assignment (10%)
    - Presentation (10%)
  - Midterm (20%)
  - Final Term (50%)

Recommended Books:

1. Pattern Recognition: An Algorithmic Approach, by M. Narasimha Murty, V. Susheela Devi
2. Pattern Recognition and Signal Analysis in Medical Imaging, by Anke Meyer-Baese, Volker J. Schmid

Biomaterials and Drug Delivery

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0
Total	=48	Total	=3.0

Course Outline:

1. **Introduction to Biomaterials**
   a. Introduction to Materials in Medicine / Logistics General Biomaterials;
   b. Polymers
   c. Cell Biology, Physiology, and Bonding
   d. Mechanical Properties of Biomaterials
   e. Polymers & Composites

2. **Drug Delivery Fundamentals**
   a. Fundamentals and challenges of drug delivery
   b. Barriers to Drug Delivery
   c. In vitro models in drug discovery and delivery
   d. Routes of Drug Delivery
   e. Pharmacokinetics
   f. Pharmacodynamics
   g. Diffusion in Biological Systems
   h. Drug Metabolism
   i. Polymer Selection
   j. Polymer Characterization

k. Hydrogel drug delivery systems
l. Polymer Microparticles/Nanop
m. articles/Micelles/Vesicles
n. Polymer-Drug Conjugates
o. Implantable Drug Delivery Systems
p. Drug Delivery in Tissue Engineering
q. Controlled Release Drug Delivery
r. Mucoadhesive Drug Delivery Systems
s. Stimuli-Responsive Polymer Delivery Systems
t. Affinity Based Drug Delivery
u. Drug Targeting
v. Prodrugs/Bioconjugation

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  - Sessional (30%)
    - Quiz (10%)
    - Assignment (10%)
    - Presentation (10%)
  - Midterm (20%)
  - Final Term (50%)

Recommended Books:

1. Advanced Biomaterials in Biomedical Engineering and Drug Delivery Systems, edited by Naoya Ogata, Sung Wan Kim, Jan Feijen, Teruo Okano
2. Advanced Biomaterials: Fundamentals, Processing, and Applications; Bikramjit Basu, Dhirendra S. Katti, Ashok Kumar, ISBN: 978-0-470-19340-2
3. Biomaterials for Drug Delivery and Tissue Engineering:, Volume 662, Surya Mallapragada, Mark Tracy, BalajiNarasimhan, Edith Mathiowitz, Richard KorsmeyerCambridge University Press, 05-Jun-2014
4. Nanobiomaterials in Drug Delivery: Applications of Nanobiomaterials, by Alexandru Mihai Grumezescu, Elsevier Science, 26-Apr-2016

Advanced Biomedical Instrumentation

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0
Total	=48	Total	=3.0

Course Outline

1. **Biopotential Amplifiers**
   a. Basic Amplifier Requirements
   b. Special Circuits
2. **Bioelectric Impedance Measurements**
   a. Measurement Methods
   b. Modeling and Formula Development
   c. Respiration Monitoring
   d. and Apnea Detection
   e. Peripheral Blood Flow
   f. Cardiac Measurements
   g. Impedance Spectroscopy
3. **Clinical Laboratory: Non-Spectral Methods and Automation**
   a. Particle Counting and Identification
   b. Electrochemical Methods
   c. Ion-Specific Electrodes
   d. Radioactive Methods
   e. Coagulation Timers
   f. Osmometers
   g. Automation
   h. Trends in Laboratory Instrumentation
4. **Implantable Devices**
   a. Implantable Cardiac Pacemakers
   b. Implantable Defibrillators
   c. Motor Cortex stimulation
   d. Implantable Stimulators for Neuromuscular Control
5. **Electrosurgical Devices**
   a. Theory of Operation
   b. Monopolar Mode
   c. Bipolar Mode
   d. ESU Design
   e. Active Electrodes
   f. Dispersive Electrodes
   g. ESU Hazards
   h. Recent Developments
6. **Parenteral Infusion Devices**
   a. Performance Criteria for Intravenous Infusion Devices
   b. Flow Through an IV Delivery
   c. Intravenous Infusion Devices
   d. Managing Occlusions of the Delivery System
7. **Essentials of Anesthesia Delivery**
   a. Gases Used During Anesthesia and Their Sources
   b. Gas Blending and Vaporization
   c. Breathing Circuits
   d. Gas Scavenging Systems

e. Monitoring the Function of the Anesthesia Delivery System
f. Monitoring the Patient

8. Biomedical Lasers

a. Interaction and Effects of UV-IR Laser Radiation on Biologic Tissues
b. Penetration and Effects of UV-IR Laser Radiation into Biologic Tissues
c. Effects of Mid-IR Laser Radiation
d. Effects of Near-IR Laser Radiation
e. Effects of Visible-Range Laser Radiation
f. Effects of UV Laser Radiation
g. Effects of Continuous and Pulsed IR-Visible Laser Radiation and
h. Association Temperature Rise
i. General Description and Operations of Lasers
j. Biomedical Laser Beam Delivery Systems

9. Medical Instruments and Devices Used at Home

a. Scope of the Market for Home Medical Devices
b. Unique Challenges to the Design and Implementation of High-Tech Homecare Devices
c. Infant Monitor Example

10. Virtual Instrumentation: Applications in Biomedical Engineering

a. Overview
b. Virtual Instrumentation and Biomedical Engineering

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  - Sessional (30%)
    - Quiz (10%)
    - Assignment/Project (10%)
    - Presentation (10%)
  - Midterm (20%)
  - Final Term (50%)

Recommended Book:

1. John G. Webster (Editor), Medical Instrumentation 2nd & 3rd ed.
2. Bengt Nolting, Methods in Modern Physics.
3. Cromwell, Bio-Medical Instrumentation & Measures 2nd ed.
4. I.D. Campbell & Ragmod A. Dwel, Biological Spectroscopy. The Benjamin Publications.
5. Ramrit Sood, Medical Laboratory Technology: Methods and Interpretations, 2003, Jaypee Brothers, New Delhi.
6. Leslie Cromwell, Fred J. Weiball and Erich, A. Pleiffer, Biomedical

Advanced Biomaterials

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0.0	Practical	=0.0
Total	=48	Total	=3.0

Course Outline:

1. **Principles of materials science and mechanical properties**
   a. Refresher on basic concepts: the structure of solids, static mechanical properties eg stress, strain, failure, fracture toughness,
   b. Multiaxial load analysis, simple bending, dynamic mechanical properties eg fatigue, viscoelasticity, creep
   c. Mathematical models of materials, tribology, wear, lubrication, testing methodology. Manufacturability.
2. **Polymers**
   a. Mechanical properties of polymers and their relationship to polymer structure
   b. molecular weight
   c. crystallinity
   d. fillers
   e. plasticizers and cross-linking
   f. Applications of polymers in medicine, eg soft tissue augmentation or repair, medical device coverings, catheters, sutures, tools, devices and problems with current generation polymers for their applications
3. **Biological materials**
   a. Mechanical properties and structures of tendons, ligaments, bone and cartilage, soft tissues
   b. Applications of devices made from materials of biological origin (eg. coraline hydroxyapatite, collagen implants)
   c. Problems of use of treated biological tissues (resorption, inflammation, disease). Manufacturability
4. **Ceramics**
   a. Mechanical properties and production of bioceramics
   b. Inert (Al2O3, zirconias, silicon nitride) and bioactive (hydroxyapatite and other calcium phosphates, bioglass, calcium sulphates).
   c. Applications of ceramics in medicine (artificial joints, coatings, heart valves) and problems with use of ceramics (wear particles, poor union to bone). Manufacturability.
5. **Metals**
   a. Properties of the major metals in use in medicine (316L stainless steel, cobalt chrome, titanium and titanium alloys).
   b. Manufacturability and Applications in orthopaedics (eg. joints, plates screws, rods, bars), dentistry (dental implants, braces, fillings)

c. Neurological implants (eg. cochlear, pacemaker)
d. General surgery (tools)
e. Problems with metals including corrosion, heavy metal ion release, wear and ductile failure.

6. Composites

a. Mechanical behaviour of composites and their use to optimize mechanical properties.
b. Composite behaviour for simple classes of clinically useful composites.
c. Applications of composites in dentistry and medicine (fillings, artificial skin, bone plates, bone substitutes and devices)
d. Problems with composite in medicine (eg. matrix failure, delamination).

7. Characterization of Biomaterials

a. Physical and Chemical Characterization of Biomaterials
b. Mechanical Characterization of Biomaterials
c. Surface Characterization of Biomaterials,
d. In Vivo Characterization of Biomaterials
e. In Vitro Characterization of Cell–Biomaterials Interactions

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  - Sessional (30%)
    - Quiz (10%)
    - Assignment (10%)
    - Presentation (10%)
  - Midterm (20%)
  - Final Term (50%)

Recommended Books:

1. Biomaterials, J.B. Park and R.S. Lakes
2. Introduction to Biomaterials: Basic Theory with Engineering Applications, C. Mauli Agrawal, Joo L. Ong, Mark R. Appleford, Gopinath Mani (Cambridge Texts in Biomedical Engineering
3. Characterization of Biomaterials, Edited by: Amit Bandhyopadhya and Susmita Bose, ISBN: 978-0-12-415800-9, 2013.
4. ENCYCLOPEDIA OF MLATERIALS CHARACTERIZATION, EDITORS C RicbardBrundle Charles A. Evans, Jr. SbaunWihon, MANAGING EDITOR Lee E. Fitzpatrick, UTTERWORTH-HEINEMANN, 1992.

Advanced Digital Signal Processing

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0.0	Practical	=0.0
Total	=48	Total	=3.0

Course Outline:

1. **Review of Signals and Systems**
   a. Continuous-time signals and Discrete-time signals
   b. Sampling of continuous-time signals
   c. Sampling theorem
   d. Linear Time-Invariant systems
   e. difference equation
   f. Unit Impulse and Convolution sum
   g. Cross correlation and Auto-correlation
2. **Transforms of the discrete domain**
   a. The discrete Fourier transform
   b. The Z transform
   c. Pulse transfer function (PTF)
   d. Obtaining PTF from a difference equation
3. **Time Frequency Analysis Methods**
   a. Short time Fourier Transform
   b. Wavelet Transform
   c. Wigner Distribution
4. **Digital filter design**
   a. Fundamental concepts of filters
   b. Filter approximations
   c. Ideal filters
   d. Concepts of FIR and IIR systems
   e. Design of FIR filters using Window method
   f. Methods of IIR filter Design
   g. Spectral Estimation
5. **Advanced Methods in Signal Processing**
   a. Basic Wiener filter theory
   b. Parametric and Adaptive Signal Processing
   c. Least Squares Method
   d. Recursive LSM
   e. Multi-rate signal processing
   f. Data Compression and Clustering

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**

Sessional (30%)
- Quiz (10%)
- Assignment (10%)
- Presentation (10%)

Midterm (20%)
Final Term (50%)

Recommended Books:

1. Signals and Linear Systems Analysis, Gordon E. Carlson, 2nd Edition, 1998, ISBN: 978-0471124658
2. Digital Signal Processing for Measurement Systems: Theory and Applications, Gabriele D'Antona, 2006, ISBN: 9780387249667
3. Digital Signal Processing: Principles, Algorithms, and Applications, John G. Proakis, 4th Edition, 2007, ISBN: 9788131710005
4. Digital Signal Processing: A Practical Approach, Emmanuel C. Ifeachor, 2nd Edition , 2002, ISBN: 9788131708248

Advances in Tissue Engineering

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=00	Practical	=0.0
Total	=48	Total	=0.0

Course Outline:

1. **Introduction**
   a. Cell and Tissue Engineering
   b. Biomaterials-Tissue Engineering
   c. Design of Medical Devices/Implants
   d. Application of Tissue Engineering
   e. Extracellular Matrix: Structure and Function
   f. Microfluidics and Bioprinting Microchannels
   g. Drug Delivery Systems for Tissue Engineering and Regenerative Medicine
   h. Nanotechnology Approaches for Tissue Engineering

2. **Stem Cells and Tissue Engineering**
   a. Basic biology to cell-based applications
   b. Cell Adhesion
   c. Cell differentiation
   d. Peptide Adhesion
   e. Protein Coatings
   f. Somatic cell reprogramming
   g. Hematopoietic stem cells
   h. Mesenchymal stem cells for tissue regeneration
   i. Delivery vehicles for deploying mesenchymal stem cells in tissue repair
   j. Stem cells for cardiac tissue engineering

k. Wound repair

3. Scaffolds

a. Scaffolding materials
b. Biologically Active Scaffolds based on Collagen-GAG Copolymers
c. Alginate for Tissue Engineering
d. Polysaccharides Scaffolds for Tissue Engineering
e. Role of Gelatin in the Release Carrier of Growth Factor for Tissue Engineering
f. Fibrillar Fibrin Gels
g. Photopolymerization of Hydrogel Scaffolds

4. Scaffold Fabrication Technologies

a. Salt-Leaching for Polymer Scaffolds
b. Solid Freeform Fabrication of Tissue Engineering Scaffolds
c. Gas Foaming to Fabricate Polymer Scaffolds in Tissue Engineering
d. Injectable Systems for Cartilage Tissue Engineering
e. Immunoisolation Techniques
f. Self-Assembled Monolayers in Mammalian Cell Cultures
g. Self-assembling Peptide Nanofiber Scaffolds

5. Cartilage tissue engineering

a. Introduction
b. Cell sources for cartilage tissue engineering
c. Adult stem cells for articular cartilage tissue engineering
d. Differentiation of Human Induced Pluripotent Stem Cells to Chondrocytes
e. Gene Transfer and Gene Silencing in Stem Cells to Promote Chondrogenesis
f. Hydrogels for cartilage tissue engineering
g. Decellularized Extracellular Matrix Scaffolds for Cartilage Regeneration
h. Scaffolds for Controlled Release of Cartilage Growth Factors
i. Nanostructured Capsules for Cartilage Tissue Engineering
j. Stratified Scaffolds for Osteochondral Tissue Engineering
k. Bioreactors for Cartilage Tissue Engineering
l. Proteomic Analysis of Engineered Cartilage
m. Mechanical Testing of Cartilage Constructs

6. Bone Tissue Engineering

a. Bone Structure and Function
b. Matrix Mineralisation
c. Osteoblast Structure and Function
d. Osteoclast Structure and Function
e. Bone Regeneration
f. Bone Biomechanics
g. Bone Repair Strategies
h. Cell Development
i. Cell Sources

j. Marrow-derived Stem Cells
k. Determined Bone Cells
l. Materials for Bone tissue engineering

7. **Bioreactors for Tissue Engineering**
8. **Ethical consideration in tissue engineering**

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  - Sessional (30%)
    - Quiz (10%)
    - Assignment (10%)
    - Presentation (10%)
  - Midterm (20%)
  - Final Term (50%)

Recommended Books:

1. Advances in Tissue Engineering, edited by Julia M. Polak, Sakis Mantalaris, Sian E. Harding
2. Advances on Modeling in Tissue Engineering, edited by Paulo Rui Fernandes, Paulo Jorge Bártolo
3. Cell and Material Interface: Advances in Tissue Engineering, Biosensor, Implant, and Imaging Technologies, Nihal Engin Vrana, CRC Press, 05-Nov-2015
4. Tissue and Organ Regeneration: Advances in Micro- and Nanotechnology, edited by Lijie Grace Zhang, Ali Khademhosseini, Thomas Webster

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Invasive and non-Invasive Brain Computer Interface

Contact Hours:	**Credit Hours:**
Theory =48	Theory =3.0
Practical = 0	Practical = 0.0
Total = 48	Total = 3.0

This course is design to learn about the Sensors and its application in medicine and health care system which include blood glucose monitoring, health care monitoring, Optical monitoring and home health care system.

Course Outline:

1. **Introduction to Brain Computer Interface**
   a. What is Brain Computer Interface

b. Measuring Brain activity
c. Application of BCI

2. **Brain Signal for Brain Computer Interface**
   a. Need for BCI
   b. Key Principle of BCI
   c. Origin of Brain Signal in the BCI
   d. Non Invasive Brain Signals
   e. Invasive Brain Signals
3. **Brain Computer Interface in Neuro-Rehabilitations**
   a. Introduction
   b. Brain–Computer Interfaces for Communication in Complete
   c. Brain–Computer Interfaces in Stroke and Spinal Cord Lesions
   d. The “Emotional” BCI
   e. Future of BCI in Neurorehabilitation
4. **Non Invasive BCIs for Neuroprostheses Control**
   a. Introduction
   b. Spinal Cord injuries
   c. Neuroprostheses for the Upper Extremity
   d. Brain-Computer Interface for Control of Grasping
   e. Interferences of Electrical Stimulation with the BCI
5. **Brain–Computer Interfaces for Communication and Control in Locked-in Patients**
   a. Introduction
   b. Locked-in the Body and Lock-Out of Society
   c. BCI Applications for Locked-in Patients
   d. Experiences of a BCI
   e. BCI Training with Patients
   f. Neonatal Monitoring
6. **Intra-cortical BCIs**
   a. Introduction
   b. Why Penetrate the Brain?
   c. History of Intra-cortical BCIs
   d. Intra-cortical Microelectrodes

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  Sessional (30%)

Quiz (10%)
Assignment (10%)
Presentation (10%)
Midterm (20%)
Final Term (50%)

Text and Reference Books:

1. Brain-Computer Interface Revolutionizing Human-Computer Interaction, Graimann, Bernhard, Allison, Brendan Z.,
2. Brain-Computer Interfaces 1: Methods and Perspectives, by Maureen Clerc (Editor), Laurent Bougrain (Editor), Fabien Lotte (Editor), ISBN: 978-1-84821-826-0, July 2016
3. Brain-Computer Interfaces 2: Technology and Applications, by Maureen Clerc (Editor), Laurent Bougrain (Editor), Fabien Lotte (Editor), ISBN: 978-1-84821-963-2, August 2016
4. Brain-Computer Interfaces: Lab Experiments to Real-World Applications, Volume 228, 1st Edition, **Serial Volume Editors:** Damien Coyle, **eBook ISBN:** 9780128092620, **Hardcover ISBN:** 9780128042168

Advanced Biomechanics

Contact Hours:	**Credit Hours:**
Theory = 48	Theory = 3.0
Practical = 0.0	Practical = 0.0
Total = 48	Total = 3.0

Course Outline:

1. **Properties**
   a. Material properties of bone & cross-sectional properties.
   b. The mechanics of Joints.
   c. Measuring techniques of force, pressure, acceleration, strain.

2. **Dynamics of (planar) segmental systems**
   a. Degrees of freedom
   b. Free-body diagrams
   c. Force and moment equilibrium
   d. Equations of motion
   e. Muscle moment arms
   f. Numerical integration of equations of motion and computational examples
   g. Mechanical properties of soft tissue Muscle

3. **Tendon and ligament**
   a. Muscle modeling
   b. Hill-type models and Computational examples
   c. Equations for Musculotendon dynamics

4. **Muscle Activation Dynamics**
   a. Excitation-contraction dynamics
   b. First-order model for activation dynamics

c. Analysis of Biomechanical Systems
d. Inverse Dynamics
e. Forward Dynamics

5. **Determining Muscle Forces**
   a. Indeterminate problem in biomechanics
   b. Static optimization method
   c. Dynamic optimization method.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  - Sessional (30%)
    - Quiz (10%)
    - Assignment (10%)
    - Presentation (10%)
  - Midterm (20%)
  - Final Term (50%)

Text and Reference:

1. Biomechanics of the Musculoskeletal System. Edited by B. Nigg and W. Herzog, Second Edition, Wiley 1999.
2. Pandy MG, Barr RE. Biomechanics of the Musculoskeletal System, Handbook of Biomedical Engineering, McGraw-Hill, 2002.

Biomedical Sensors

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0.0
Total	=48	Total	=3.0

This course is design to learn about the Sensors and its application in medicine and health care system which include blood glucose monitoring, health care monitoring, Optical monitoring and home health care system.

Course Outline:

1. **Introduction to Sensors**
   a. Sensors and transducers
   b. Types of Sensors
   c. Conventional sensor used in Biomedical Engineering

2. **Optical Sensors in Medical Care**
   a. Optical sensors
   b. The Diagnostic/Therapeutic

c. Propagation of Light in Tissue
d. Transport Theory
e. Diffusion Theory and Monte Carlo Models
f. Near IR Spectroscopy
g. Scattering
h. Brain Spectroscopy
i. Fick's Law Applied to Brain Blood Flow

3. Biosensors for Glucose Monitoring

a. biosensors;
b. monitoring of glucose;
c. diabetes;
d. monitoring principles;
e. amperometric glucose biosensors;
f. home blood glucose monitors;
g. laboratory analyzers;
h. implantable sensors;
i. minimally-invasive systems;
j. non-invasive systems

4. Sensors for respiratory System

a. respiratory monitoring;
b. airflow detection;
c. thermal flow;
d. humidity;
e. carbon dioxide;
f. indirect sensors;
g. non-contact devices;
h. invasive sensors;
i. pressure sensors;
j. blood gas monitors

5. Sensors for Fetal and Neonatal Monitoring

a. fetal and neonatal monitoring;
b. sensor requirements;
c. safety and convenience;
d. Fetal Near Infrared Spectroscopy (NIRS)
e. Neonatal Monitoring
f. Temperature Monitoring
g. Breathing
h. pH and Blood Gases
i. Cardiac Monitoring
j. Cerebral Monitoring

6. Home Health Care and Telecare

a. Introduction
b. Blood Pressure
c. Respiration
d. Blood Oxygenation

e. Body Temperature
f. Electrocardiogram
g. Heart Rate and Pulse Rate
h. Blood Components
i. Urine Components
j. Body Weight
k. Body Fat
l. Daily Activity
m. Sleep

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  - Sessional (30%)
    - Quiz (10%)
    - Assignment (10%)
    - Presentation (10%)
  - Midterm (20%)
  - Final Term (50%)

Text and Reference Books:

1. Sensors in Medicine and Health Care: Sensors Applications, Volume 32. P. Å. Öberg, Tatsuo Togawa, Francis A. Spelman
2. Sensors in Biomedical Applications: Fundamentals, Technology and Applications, By Gabor Harsanyi

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Biostatistics

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0.0
Total	=48	Total	=3.0

This course is a reasonably thorough treatment of the theory of probability and statistics. The course aims to give advanced concepts of statistics as applied in biomedical engineering.

Course Outline:

1. **Statistics and Estimation**
   a. Descriptive Statistics
   b. Bayes' theorem, Bayesian Inference
   c. Discrete Probability Distributions
   d. Continuous Probability Distributions
   e. Central limit theorem
   f. Confidence Interval and Estimation.

2. **Regression and Correlation**
    a. The Regression Model
    b. Sample Regression Equation
    c. The Correlation Model
    d. The Correlation Coefficient
    e. Multiple Linear Regression Model
    f. Multiple Regression Equation
    g. Multiple Correlation Model
3. **Chi-Square Distribution and Analysis of Frequencies**
    a. Mathematical Properties Chi-Square Distribution
    b. Tests of Goodness-Of-Fit
    c. Tests of Independence
    d. Tests of Homogeneity
    e. The Fisher Exact Test
    f. Relative Risk, Odds Ratio, And The Mantel–Haenszel Statistic
4. **Nonparametric and Distribution-Free Statistics**
    a. Measurement Scales
    b. The Sign Test
    c. The Wilcoxon Signed-Rank Test for Location
    d. The Median Test
    e. The Mann–Whitney Test
    f. The Kolmogorov–Smirnov Goodness-Of-Fit Test
    g. The Kruskal–Wallis One-Way Analysis of Variance by Ranks
    h. The Friedman Two-Way Analysis of Variance by Ranks
    i. The Spearman Rank Correlation Coefficient
    j. Nonparametric Regression Analysis

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
    - Sessional (30%)
        - Quiz (10%)
        - Assignment (10%)
        - Presentation (10%)
    - Midterm (20%)
    - Final Term (50%)

Recommended Books:

1. Fundamentals of Biostatistics, Bernard Rosner, 7th Edition, 2010, ISBN-13: 978-0538733496

2. Biostatistics: A Foundation for Analysis in the Health Sciences, 10th Edition, Wayne W. Daniel, 2013, ISBN-13: 978-1118302798
3. Probability and Statistics for Engineers and Scientists, Ronald E. Walpole, 9th Edition, 2011, ISBN-13: 978-0321629111

Advanced Medical Image Processing

Contact Hours:
Theory =48
Practical = 0
Total = 48

Credit Hours:
Theory = 3.0
Practical = 0.0
Total = 3.0

Course Outlines:

1. **Fundamental Concepts of Image Processing**
   a. Fundamentals of digital image processing
   b. The gray-level histogram
   c. Histogram transformations and look-up tables
   d. Digital Image Processing and its applications
   e. Medical images
2. **Image Reconstruction**
   a. Radon transform
   b. Central slice theorem
   c. Back Projection Method
   d. Iterative Algebraic Reconstruction
3. **Basic Gray Level transformations**
   a. Image Negative
   b. Log transform
   c. Gamma correction
4. **Image Enhancement in the Spatial Domain**
   a. Algebraic operations
   b. Logical (Boolean) operations
   c. Geometric operations
   d. Convolution-based operations
5. **Image Enhancement in the Frequency Domain**
   a. Point spread function and optical transfer function
   b. Frequency domain filters
   c. Tomographic reconstruction
6. **Image Restoration**
   a. Image degradation
   b. Noise-reduction filters
   c. De-blurring
   d. Modeling image degradation
   e. Geometric degradations
   f. Morphological image processing
   g. Mathematical morphology

h. Morphological operators
i. Extension to gray-scale images

7. Image Segmentation

a. Introduction
b. Thresholding
c. Region-based methods
d. Boundary-based methods

8. Image Classification

a. Object recognition and classification
b. Statistical classification
c. Structural/syntactic classification
d. Applications in medical image analysis

9. Image Processing algorithms

Advanced image processing algorithms applied to analysis of medical images;

a. Image segmentation (level sets, watershed, active contours) and image registration (mutual information, Thirion Demons, B Spline algorithms)
b. Development and application of these algorithms using ITK Toolkit.
c. Medical Image Enhancement, automatic Understanding & Diagnostic Systems.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  - Sessional (30%)
    - Quiz (10%)
    - Assignment (10%)
    - Presentation (10%)
  - Midterm (20%)
  - Final Term (50%)

Recommended Books:

1. Digital Image Processing for Medical Applications, by Geoff Dougherty
2. Digital Image Processing, by R. Gonzalez and R. Woods
3. Biosignal and Biomedical Image Processing MATLAB-Based Applications, by John L. Semmlow

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Neuralengineering

Contact Hours:
Theory = 48
Practical = 0.0
Total = 48

Credit Hours:
Theory = 3.0
Practical = 0.0
Total = 3.0

Course Outline:

1. **Microscopic Level**
   a. Technology of Electrophysiology
   b. Membrane and Ion Channels
   c. Single cell physiology
   d. Biophysics of the neuron
   e. Hodgkin-Huxley-model of action potentials.
2. **Macroscopic Level**
   a. Nervous system, motor nervous system and their functionality
   b. Brain Stimulation and Diseases
   c. Brain pacemaker
   d. Human Brain Interfaces
   e. Neural Recording Techniques.
3. **Functional level**
   a. Neural basis of cognition
   b. Neurophysiological studies in humansusing fMRI, PET, MEG, EEG, and TMS.
   c. Motor control and learning.
4. **The Brain and Its Functions**
   a. Brain waves and Electroencephalogram
   b. Evoked Potentials
   c. Diseases of the Central Nervous System
   d. EEG for Assessment of Anesthesia
   e. Sleep Studies
5. **Neural Interfaces**
   a. Neural interfacing for sensory and motor prosthetics
   b. Neural interfacing for treatment of disease (functional electrical stimulation)
   c. Neural interfacing for in vitro brain models
6. **Brain stimulation**
   a. Effects and safety of electrical stimulation
   b. Models of neural stimulation
   c. Power and control of devices
   d. Electrodes for central stimulation and recording
   e. Electrodes for peripheral stimulation and recording
7. **Neural Signal Processing**
   a. Real-time neural data analysis and feedback
   b. Neurally-controlled robots
   c. Diagnostic neural interfacing

8. **Electromyogram**
    a. Muscle
    b. EMG
    c. Neuromuscular Diseases and the EMG
9. **Other Biomedical Signals**
    a. NIRS
    b. TMS
    c. Electro-oculogram
    d. Magneto-encephalogram

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
    - Sessional (30%)
        - Quiz (10%)
        - Assignment (10%)
        - Presentation (10%)
    - Midterm (20%)
    - Final Term (50%)

Text and Reference:

1. Neuroprosthetics - Theory and Practice (KW Horch and GS Dhillon, eds), Volume 2 in the Series on Bioengineering and Biomedical Engineering, 2004, World Scientific Publishing, is a suggested reference.
2. Dayan, P, Abbott, LF (2001) Theoretical neuroscience
3. Windhorst U, Johansson H (1999) Modern Techniques in Neuroscience Research, 1 Edition. Berlin: Springer
4. Kandel ER, Schwartz JH, Jessel TM (1991) Principles of neural science, Prentice-Hall
5. Koch C, Segev I (1998) Methods in Neuronal Modelling, 2nd Edition. Cambridge, MA: MIT Press

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Operations Management

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0	Practical	=0.0
Total	=48	Total	=3.0

Course Outline:

1. **Introduction to Operations Management**
    a. Current issues in operations management

b. Strategic role of operations
c. Strategy in context of manufacturing and service

2. **Policy**
   a. Developing new products and Services
   b. Innovation
   c. New Product Development (NPD) Process
   d. Best practice in NPD
   e. Factors affecting process design
   f. Types of generic process
   g. Physical layout
   h. Trends in process design

3. **Manufacturing**
   a. Managing Supply
   b. Capacity
   c. Throughput and Quality
   d. Understanding Supply
   e. Evolution from purchasing to supply
   f. Sourcing strategies

4. **Demand and Supply Relationship**
   a. Understanding capacity.
   b. Determinants of demand
   c. Strategies for matching supply and demand
   d. Managing throughput

5. **Performance Improvement**
   a. Improving operations flows
   b. Quality standards and certification
   c. Service quality
   d. Total quality Management
   e. Performance measurement
   f. Continuous improvement
   g. Radical performance improvement
   h. Importance of human resources
   i. Quality and innovation in World Class Operations
   j. Advanced Operational Research Techniques

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  Sessional (30%)

Quiz (10%)
Assignment (10%)
Presentation (10%)
Midterm (20%)
Final Term (50%)

Recommended Books:

1. Operations Management: Policy, Practice and Performance Improvement, Steve Brown, Kate Blackmon, Paul Cousins, Harvey Maylor, 2001, ISBN: 978-0750649957, ISBN: 0 7506 4995 X

Systems Physiology

Contact Hours:		**Credit Hours:**	
Theory	=48	Theory	=3.0
Practical	=0.0	Practical	=0.0
Total	=48	Total	=3.0

Course Outline:

1. **Human anatomy and physiology from a system's view point**
   a. Quantitative issues at the organ and whole body levels of:
   b. Cardiovascular
   c. Respiratory
   d. Renal
   e. Digestive systems.
2. **Nerve and Muscle**
   a. Membrane potential,
   b. Action potential,
   c. Excitation and Rhythmicity.
   d. Contraction of Skeletal and cardiac muscles,
   e. Sliding filament Mechanism
   f. Heart as a pump
3. **Sensory Systems**
   a. Sensory Receptors,
   b. Classification and basic mechanism of action
4. **Special Senses**
   a. Eye
   b. Receptor function of the retina
   c. Neurophysiology of Vision
5. **Sound**
   a. Structure and functions of the auditory systems
6. **Nervous System**
   a. Organization of Nervous System
   b. Basic functions of synapses

c. Neuronal Mechanism and circuits for processing information.
d. Spinal cord and the cord reflexes
e. Cerebral cortex and intellectual functions of the Brain
f. Motor function of the Brain stem
g. Vestibular control of postural reflexes
h. Cerebrum and basal ganglia
i. Limbic System
j. Role of the Hypothalamus
k. The Autonomic nervous system
l. Neural and neuroendocrine control of the circulation

7. Endocrinology and Reproduction

a. Introduction to Endocrinology and the pituitary Hormones
b. Hormonal functions in male and female.

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  - Sessional (30%)
    - Quiz (10%)
    - Assignment (10%)
    - Presentation (10%)
  - Midterm (20%)
  - Final Term (50%)

Text and Reference:

1. Arthur C. Guyton, John E. Hall: Textbook of Medical Physiology. Amsterdam: Elsevier
2. William H. Howell: A Textbook Of Physiology For Medical Students And Physicians
3. Drake, R., Wayne Vogl, A., Mitchell, A.: Gray's Anatomy for students.
4. Churchill Livingstone Tortora/Grabowski: Principles of Anatomy and Physiology.
5. **Chappell**, Michael, **Payne**, Stephen, Physiology for Engineers: Applying Engineering Methods to Physiological Systems, 2016
6. Medical Terminology - A Systems Approach, 4th Ed., by Gylys and Wedding, F.A. Davis Co.

Ultrasonic Instrumentation and Imaging

Contact Hours: **Credit Hours:**

Theory	=48	Theory	=3.0
Practical	=0.0	Practical	=0.0
Total	=48	Total	=3.0

Course Outline:

1. **Physics of ultrasound**
   a. Fundamentals of Ultrasound
   b. Ultrasound Echoes
   c. Wave Equation
   d. Impedance, Power, Reflection, Scattering, Attenuation
   e. Single-element and array transducers
   f. Scanning Modes
2. **Ultrasound Fields**
   a. Continuous wave
   b. Pulsed Pressure
   c. Pulse Echo fields
   d. Axial and Lateral Resolution
   e. Focal Spot Size
   f. Ultrasound nonlinearity
3. **Principles of ultrasound imaging and instrumentation**
   a. A-Mode, B-Mode, M-Mode, C-Mode
   b. Doppler Ultrasound
   c. Tissue Harmonic imaging,
   d. Contrast Harmonic imaging
   e. Sub-harmonic and Super-harmonic imaging
   f. Elasticity imaging,
   g. Photoacoustic tomography
   h. Acoustic Microscope
4. **Ultrasound Applications**
   a. Ultrasound tissue characterization
   b. Micro-bubble contrast agents
   c. Blood flow measurement
   d. Ultrasound in drug delivery
   e. High intensity focused ultrasound (HIFU) for therapy

Suggested Teaching Methodology:

- Lecturing
- Written Assignments
- Report Writing
- Presentations

Suggested Assessment:

- **Theory (100%)**
  Sessional (30%)
  Quiz (10%)
  Assignment (10%)
  Presentation (10%)

Midterm (20%)
Final Term (50%)

Recommended Books:

1. Diagnostic Ultrasound Imaging: Inside Out, Thomas L. Szabo, 2nd Edition, 2013, ISBN-9780123964878
2. Biomedical Technology and Devices, Handbook, Ed: James Moore, George Zouridakis, 2004, ISBN: 0-8493-1140-3
3. Biomedical Signal and Image Processing, KayvanNajarian, Robert Splinter, 2nd Edition, 2012, ISBN: 978-1-4398-7033-4
4. Richard S. C. Cobbold "Foundations of Biomedical Ultrasound", 2006, ISBN: 13978-0-19-516831-0

Note:

New Elective courses may be introduced according to latest developments and available resources.

BM-699 Master Thesis 6 C.hr.

Student has to take a topic for literature review and research under the supervision of his advisor. HE/She has to submit the results of his findings in the form of a thesis/report and defend his findings in front of a panel of experts.

RECOMMENDATIONS

1. Hospital/industry visits to be made more meaningful and related to Biomedical Engineering domain in the curriculum.

2. Since MBBS/BDS and other relevant disciplines do not have the pre-requisite to undertake Masters in Biomedical Engineering program. Therefore, other institutions may consider offering MS Biomedical Sciences or similar programs for MBBS/BDS and allied health and natural sciences streams.

3. PhD Biomedical Engineering programme may be undertaken by the institution that fulfill HEC criteria for the same.

4. Regular seminars should be held at National level through a formalized Outreach Program for all stakeholders **to increase awareness about Biomedical Engineering profession** and bring out the true potential of this discipline.

   The stakeholders include:
   - Students and academicians of schools, colleges, Universities and technical institutes.
   - Administrative and professional staff, decision and policy makers of hospitals and healthcare delivery organizations and service providers including government and private healthcare departments, R&D Institutions, and the healthcare industry.

   The outreach program and presentation seminars should be designed to h**elp promote interaction and working relationships** among the stakeholders.

5. Relevant regulatory bodies should require all hospitals to establish a department of Biomedical Engineering and employing qualified registered Biomedical Engineers.

6. A specialized journal in the field of Biomedical Engineering shall be launch under the patronage of HEC, Pakistan.

Annex "A"

COMPULSORY COURSES IN ENGLISH FOR BE/BSc IN ENGINEERING DISCIPLINE

Functional English

Objectives: To enhance language skills and develop critical thinking

Course Contents:

Basics of Grammar
Parts of speech and use of articles
Sentence structure, Active and passive voice
Practice in unified sentence
Analysis of phrase, clause and sentence structure
Transitive and intransitive verbs
Punctuation and spelling

Comprehension

Answers to questions on a given text

Discussion

General topics and every day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

Listening

To be improved by showing documentaries/films carefully selected by subject teachers)

Translation skills

Urdu to English

Paragraph writing

Topics to be chosen at the discretion of the teacher

Presentation skills

Introduction

Note: Extensive reading is required for vocabulary building

Recommended books:

1. Functional English

a) Grammar

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 1. Third edition. Oxford University Press. 1997. ISBN 0194313492

2. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0194313506

b) Writing

1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.

c) Reading/Comprehension

1. Reading. Upper Intermediate. Brain Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.

d) Speaking

Communication Skills

Objectives: To enable the students to meet their real life communication needs

Course Contents:

Paragraph writing
Practice in writing a good, unified and coherent paragraph

Essay writing
Introduction

CV and job application

Translation skills
Urdu to English

Study skills
Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension

Academic skills
Letter / memo writing and minutes of the meeting, use of library and internet recourses

Presentation skills
Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review

Recommended books:
Communication Skills

a) Grammar

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.

b) Writing

1. Writing. Intermediate by Marie-Chrisitine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).

c) Reading

1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
2. Reading and Study Skills by John Langan
3. Study Skills by Riachard Yorky.

Technical Writing and Presentation Skills

Objectives: To enhance language skills and develop critical thinking

Course Contents:

Presentation skills

Essay writing
Descriptive, narrative, discursive, argumentative

Academic writing
How to write a proposal for research paper/term paper

How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency)

Technical Report writing

Progress report writing
Note: Extensive reading is required for vocabulary building

Recommended books:
Technical Writing and Presentation Skills

a) Essay Writing and Academic Writing
   1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).

   2. College Writing Skills by John Langan. Mc=Graw-Hill Higher Education. 2004.
   3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.

b) Presentation Skills
c) Reading
   The Mercury Reader. A Custom Publication. Compiled by norther Illinois University. General Editiors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharton. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

Technical Writing and Presentation Skills

Objectives: To enhance language skills and develop critical thinking

Course Contents:

Presentation skills

Essay writing
Descriptive, narrative, discursive, argumentative

Academic writing
How to write a proposal for research paper/term paper

How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency)

Technical Report writing

Progress report writing

Note: Extensive reading is required for vocabulary building

Recommended books:
Technical Writing and Presentation Skills

a) Essay Writing and Academic Writing

1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).

4. College Writing Skills by John Langan. Mc=Graw-Hill Higher Education. 2004.
5. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.

d) Presentation Skills

e) Reading

The Mercury Reader. A Custom Publication. Compiled by norther Illinois University. General Editiors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharton. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

Annex-B

ISLAMIC STUDIES (Compulsory)

COURSE PROFILE

S.NO	TITLES	DETAIL
1	**Name of Course**	**Islamic Studies(Compulsory)**
2	**No. of Credit Hours**	**2 Credit Hours**
3	**Nature of Course**	**Compulsory at Graduation Level**
4	**Total Teaching Weeks**	**18**
5	**Objectives of the Course**	This course is aimed at: 1-To provide Basic information about Islamic Studies 2-To enhance understanding of the students regarding Islamic Civilization 3-To improve Students skill to perform prayers and other worships 4-To enhance the skill of the students for understanding of issues related to faith and religious life
6	**Components of Teaching of the Course**	

LEVEL OF COURSE	GRADUATION
NAME OF DEGREE	BS
NAM OF COURSE	ISLAMIC STUDIES
SEMESTER	AS PER REQUIREMENT OF THE UNIVERSITY
NO. OF CREDIT	2
TOTAL TEACHING HOURS	AS PER HEC REQUIRMENTS
NO. OF PERIODS PER WEEK	2
TOTAL TEACHING PERIOD OF COURSE	18 WEEKS

UNIT NO.1: **INTRODUCTION TO QURANIC STUDIES**

1) Basic Concepts of Quran
2) History of Quran
3) Uloom-ul -Quran

UNIT No.2 : STUDY OF SELLECTED TEXT OF HOLLY QURAN

1) Verses of Surah Al-Baqra Related to Faith(Verse No-284-286)
2) Verses of Surah Al-Hujrat Related to Adab Al-Nabi

(Verse No-1-18)

3) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
4) Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
5) Verses of Surah Al-Inam Related to Ihkam(Verse No-152-154)

UNIT No.3 : STUDY OF SELLECTED TEXT OF HOLLY QURAN

1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.)
2) Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
3) Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14)

UNIT NO.4: SEERAT OF HOLY PROPHET (S.A.W) I

1) Life of Muhammad Bin Abdullah (Before Prophet Hood)
2) Life of Holy Prophet (S.A.W) in Makkah
3) Important Lessons Derived from the life of Holy Prophet in Makkah

UNIT NO.5: SEERAT OF HOLY PROPHET (S.A.W) II

1) Life of Holy Prophet (S.A.W) in Madina
2) Important Events of Life Holy Prophet in Madina
3) Important Lessons Derived from the life of Holy Prophet in Madina

UNIT NO.6: INTRODUCTION TO SUNNAH

1) Basic Concepts of Hadith
2) History of Hadith
3) Kinds of Hadith
4) Uloom –ul-Hadith
5) Sunnah & Hadith
6) Legal Position of Sunnah

UNIT NO.7 SELLECTED STUDY FROM TEXT OF HADITH

UNIT NO.8 INTRODUCTION TO ISLAMIC LAW & JURISPRUDENCE

1) Basic Concepts of Islamic Law & Jurisprudence
2) History & Importance of Islamic Law & Jurisprudence
3) Sources of Islamic Law & Jurisprudence
4) Nature of Differences in Islamic Law
5) Islam and Sectarianism

UNIT NO.9: ISLAMIC CULTURE & CIVILIZATION

1) Basic Concepts of Islamic Culture & Civilization
2) Historical Development of Islamic Culture & Civilization

3) Characteristics of Islamic Culture & Civilization
4) Islamic Culture & Civilization and Contemporary Issues

UNIT NO.10:**ISLAM & SCIENCE**

1) Basic Concepts of Islam & Science
2) Contributions of Muslims in the Development of Science
3) Quranic & Science

UNIT NO.11:ISLAMIC ECONOMIC SYSTEM

1) Basic Concepts of Islamic Economic System
2) Means of Distribution of wealth in Islamic Economics
3) Islamic Concept of Riba
4) Islamic Ways of Trade & Commerce

UNIT NO.12: **POLITICAL SYSTEM OF ISLAM**

1) Basic Concepts of Islamic Political System
2) Islamic Concept of Sovereignty
3) Basic Institutions of Govt. in Islam

UNIT NO.13: **ISLAMIC HISTORY**

1) PERIOD OF KHLAFT-E-RASHIDA
2) PERIOD OF UMMAYYADS
3) PERIOD OF ABBASIDS

UNITNO.14 : SOCIAL SYSTEM OF ISLAM

1) BASIC CONCEPTS OF SOCIAL SYSTEM OF ISLAM
2) ELEMENTS OF FAMILY
3) ETHICAL VALUES OF ISLAM

REFERENCE BOOKS:

1) HAMEED ULLAH MUHAMMAD, "**EMERGENCE OF ISLAM**" , IRI, ISLAMABAD
2) HAMEED ULLAH MUHAMMAD, "**MUSLIM CONDUCT OF STATE**"
2) HAMEED ULLAH MUHAMMAD, '**INTRODUCTION TO ISLAM**
3) MULANA MUHAMMAD YOUSAF ISLAHI,"
4) Hussain Hamid Hassan, **"An Introduction to the Study of Islamic Law"** leaf
   Publication Islamabad, Pakistan.
5) Ahmad Hasan, **"Principles of Islamic Jurisprudence"** Islamic Research Institute, international Islamic University, Islamabad (1993)
6) Mir Waliullah, **"Muslim Jrisprudence and the Quranic Law of Crimes"** Islamic Book Service (1982)
7) H.S. Bhatia, **"Studies in Islamic Law, Religion and Society"** Deep & Deep
   Publications New Delhi (1989)
8) Dr. Muhammad Zia-ul-Haq, **"Introduction to Al Sharia Al Islamia"** Allama Iqbal Open University, Islamabad (2001)

Annex “C”

Pakistan Studies (Compulsory)

(As Compulsory Subject for Degree Students)

Introduction / Objectives

The course has been designed as a compulsory subject for the students studying for Bachelor’s degree, general or professional. The course is of 3 credit hours carrying 100 marks (recommended). The teaching work is comprised of three dimensions: Historical Perspective (20%); Government and Politics (40%); and Contemporary Pakistan (40%).

The course framework is issue-oriented. It has many dimensions, the historical and ideological background of Pakistan the process of governance and national development as well as the issues arising in the modern, age and posing challenges to Pakistan. The course has been designed with a vision that Pakistan Studies should open a window to future.

Course Outline:

1. **Historical Perspective**
   a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-i-Azam Muhammad Ali Jinnah.
   b. Factors leading to Muslim separatism
   c. People and Land
      i. Indus Civilization
      ii. Muslim advent
      iii. Location and Geo-Physical features.
2. **Government and Politics in Pakistan**
   Political and constitutional phases:
   a. 1947-58
   b. 1958-71
   c. 1971-77
   d. 1977-88
   e. 1988-99
   f. 1999 onward
3. **Contemporary Pakistan**
   a. Economic institutions and issues
   b. Society and social structure
   c. Ethnicity
   d. Foreign policy of Pakistan and challenges
   e. Futuristic outlook of Pakistan

Books Recommended

1. Burki, Shahid Javed. *State & Society in Pakistan,* The Macmillan Press Ltd 1980.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy.* Karachi: Oxford University Press, 2000.
3. S.M. Burke and Lawrence Ziring. Pakistan's Foreign policy: An Historical analysis. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. *Pakistan Political Roots & Development.*Lahore, 1994.
5. Wilcox, Wayne.*The Emergence of Banglades.,* Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. *Pakistan Kayyun Toota,* Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
7. Amin, Tahir. *Ethno - National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development.* Kent England: WmDawson & sons Ltd, 1980.
9. Zahid, Ansar. *History & Culture of Sindh.* Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan,* Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan.* Boston: Houghton Mifflin, 1967.
12. Aziz, K.K. *Party, Politics in Pakistan,* Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, Pakistan Under Martial Law, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective.* Islamabad: National Commission on Historical and Cultural Research, 1993.

Annex "D"

COURSES FOR SOCIAL SCIENCE

Sociology and Development

(For Engineers)

Objectives: The main objective of this course is to apprise potential engineers about social factors that contribute towards enhancing their professional performance for the good of society and the country. This course is culture specific and has to be taught within the context of local and national socio-economic environment. The engineers are expected to supervise several people in different capacities and their understanding about human behaviour is critical for their optimum performance. Modification of human behaviour or getting work done from sub-ordinates and seniors remain a major challenge for all the professional engineers. This course will enhance understanding about the determinants of human behaviour, which ultimately will result in improved individual efficiency.

1. Introduction to Sociology

- 1.1 What is sociology?
- 1.2 Nature, Scope, and Importance of Sociology
- 1.3 Social Interactions
- 1.4 Social Groups
- 1.5 Social Institutions

2. Culture and Related Concepts

- 2.1 Definition of Culture
- 2.2 Types of Culture
- 2.3 Elements of Culture
- 2.4 Role of Culture in Organization
- 2.5 Socialization and Personality

3. Interpersonal Relations

- 3.1 Interpersonal Behaviour
- 3.2 Formation of Personal Attitudes
- 3.3 Language and Communication
- 3.4 Motivations and Emotions
- 3.5 Public Opinion

4. Social Stratification

- 4.1 Factors of Social Stratification
- 4.2 Caste and class
- 4.3 Power, Prestige, and Authority
- 4.4 Social Mobility
- 4.5 Migration

5. Human Ecology

- 5.1 Ecological Processes
- 5.2 Ecosystem and energy
- 5.3 Ecosystem and Physical Environment

5.4 Solid Waste Disposal
5.5 Pollution

6. Population Dynamics

6.1 World Population Growth and Distribution
6.2 Population Dynamics in Pakistan
6.3 Causes and Consequences of Urbanization
6.4 Population Policy in Pakistan
6.5 Population and Development

7. Community Development

7.1 Meaning, Scope, and Subject Matter of Community Development
7.2 Processes of Community Development
7.3 Community Development Programs in Pakistan
7.4 Community Organization and Related Services
7.5 Cooperation and Conflict in Community Development

8. Deviance and Crime

8.1 Crime as a Social and Cultural Phenomenon
8.2 Crime and Social Organization
8.3 Organized Crime
8.4 Culture Based Crime
8.5 Economics of Crime

9. Sociology of Change and Development

9.1 What is Social Change and Development?
9.2 Dynamics of Social Change
9.3 Role of NGOs in Development
9.4 World System and Development
9.5 Gender and Development

Recommended Readings

1. *Allport, G. W. (1985). The Historical Background of Modern Social Psychology. New York, Random House.*
2. *Bernard, A. and T. Burgess (2004). Sociology, Cambridge University Press.*
3. *DuBrin, A. J. (2007). Human Relations: Interpersonal Job Oriented Skills. New York, Prentice Hall.*
4. *Gardezi, H. N., Ed. (1991). Understanding Pakistan: The Colonial Factor in Societal Development. Lahore, Maktaba Fikr-o-Danish.*
5. *Hafeez, S. (1991). Changing Pakistan Society. Karachi, Royal Book Company. Gardezi, H. N., Ed. (1991).*
6. *Jones, G. W. (2005). "Why are Population and Development Issues not Given Priority?" Asia-Pasific Population Journal **20**(1).*
7. *Macionis, J. J. (1999). Sociology 7th Edition, National Book Foundation, Islamabad*
8. *Maser, C. (1997). Sustainable Community Development: Principles and Concepts. Plorida St. Lucie Press.*

9. *Nelson, N. and S. Wright (1995). Power and Participatory Development: Theory and Practice. London, Intermediate Technology Publications.*
10. *Syed, S. H. (2003). The State of Migration and Multiculturalism in Pakistan: The Need for Policy and Strategy. Islamabad, UNESCO: 1-30.*
11. *Utton, A. E. (1976). Human Ecology, West View Press.*
12. *Webster, A. (1990). Introduction to Sociology of Development. London, Nacmillan Education Ltd.*
13. *Weiss, A. M. (2001). Power and civil society in Pakistan, Oxford University press.*

SOCIAL ANTHROPOLOGY
(For Engineers)

Objectives: The students are expected to learn anthropological skills for application by professional engineers and other related practitioners. Societal growth needs are to be understood within our own cultural environment. Such a body of applied knowledge will result in improving the professional performance of would-be engineers. As culture and society play an important role towards all human activities, this course will help students relate technical skills to the societal needs and requirements.

I Introduction

1. Anthropology and Social Anthropology
2. Fields of Anthropology
3. Anthropological Research Methods
4. Social Anthropology and other Social Sciences
5. Significance of Social Anthropology

II Culture

1. Definition, Properties and Taxomony
2. Evolution of Growth and Culture
3. Evolution of Man: Religious and Modern Perspectives
4. Evolution of Culture
5. Culture and Personality

III Evolution and Growth of Culture

1. Evolution of Man
2. Schools of Thought in Cultural Anthropology
3. Acculturation
4. Enculturation
5. Ethnocentrism and Xenocentrism

IV Language and Culture

1. Communication
2. Structural Linguistics
3. Historical Linguistics
4. Relationship between Language and Culture
5. Ethnography

V Economic System

1. Global Economic System
2. The Allocation of Resources
3. The Conversion of Resources
4. The Distribution of Goods and Services
5. Poverty and Inequality

VII Marriage and Family

1. Marriage and Mate Selection
2. The Family: Types and Functions
3. Kinship System
4. Structure and Function of Family
5. Gender Relations

VIII Political Organization

1. Political Sociology
2. Origin of Political Organization and Organizational System
3. Types of Political Organizations
4. Power Politics and Factionalism in Pakistan
5. Resolution of Conflict

IX Religion and Magic

1. The Universality of Religion
2. Comparative Religions
3. Religion and Society
4. Religious Beliefs and Practices
5. Witchcraft and Sorcery

XI Culture Change

1. Forms of Art
2. Expressive Culture
3. Process of Cultural Change
4. Cultural Change in the Modern World
5. Cultural Change in Pakistani society

Recommended Books

1. *Ahmad, Akbar S. 1990. Pakistani Society, Karachi, Royal Books Co.*
2. *Bernard, H. Russel. 1994. Research Methods in Anthropology, Qualitative and Quantitative Approaches. London: Sage Publications*
3. *Bodley, John H. 1994. Cultural Anthropology, California: Mayfield Publishing Co.*
4. *Brogger, Jan. 1993. Social Anthropology and the Lonely Crowd. New Delhi: Reliance Publishing*
5. *Ember, Carol R. & Ember Melvin. 2005. Anthropology, 11th ed. Englewood Cliffs: Prentice Hall, Ince. Harper and Row*
6. *Harris Marvin. 1987. Cultural Anthropology. New York: Harper and Row*

7. *Harris Marvin. 1985. Culture, People, nature; An Introduction to General Anthropology London: Harper and Row*
8. *Haviland, W. A. (2005). Anthropology: The Human Challenge. New York, Thomson Learning Inc.*
9. *Hertzler J. O. 1981. The Social Structure of Islam. Cambridge: Cambridge University Press.*
10. *Keesing, Roger m. 1998. Cultural Anthropology: A contemporary perspective. 3rd ed. New York: Harcourt Brace College Publishers.*
11. *Kottak, Conard Phillip. 2002. Anthropology: The Exploration of Human Diversity. 9th ed. Boston: McGraw Hill Higher Education.*
12. *Kennedy, Charles H. 1992. Pakistan London: Westview Press,.*
13. *Marron, Stanley. 1057. Pakistani Society and Culture. New Heaven*
14. *Wilson, Richard A. 1996. Human Rights, Culture and Context: Anthropological Perspective. London: Pluto Press.*

Psychology
Courses for BSc/BE in Engineering Programme

Course-I **Understanding Psychology and Human Behaviour** 3 credit hrs

- What is Psychology?
- Nature, Scope and Application with Special Reference to Pakistan
- Different Schools of Psychology
- Methods of Psychology
- Learning
- Intelligence and Artificial Intelligence
- Personality and its Assessment
- Understanding Maladjustive Behaviour
- Positive Emotional States and Processes
- Stress Management and Anger Management

Books Recommended

1. Atkinson R.C., & Smith E.E. (2000), Introduction to Psychology (13th ed.), Harcourt Brace College Publishers.
2. Fernald, L.D., & Fernald, P.S. (2005), Introduction to Psychology, USA: WMC Brown Publishers.
3. Hergenhahn, B.R. (2001). An Introduction to the History of Psychology, New York: Wadsworth.
4. Goodwin, C.J, (2000) Research in Psychology: Methods and Design, (3rd ed.), New York: John Wiley & Sons.

5. Synder, C.R., & Lopez, S.J. (2007) Positive Psychology, USA, Sage Publications.
6. Allen, B.P. (1997), Personality Theories: Development, Growth and Diversity, (2nd Ed.), Boston: Allyn & Bacon.
7. Cohen, R.J., & Swerdlik, M.E. (2005) Psychological Testing & Assessment (6th ed.), New York: McGraw-Hill.
8. Corcini, R., (2000). Current Psychotherapies. London: Thompson & Co Publishers.
9. Comer, R.J. (2004). Abnormal Psychology, USA: Freeman & Company.
10. Schwartz, B., Wassernman, E., & Robbins, S. (2002), Psychology of Learning and Behaviour, 5th Ed. Norton and Company.

Course II **Professional Psychology** 3 credit hrs

- Introduction to Professional Psychology
- Psychological Testing
- Educational Psychology
- Industrial/Organizational Psychology
- Social Psychology
- Health Psychology
- Clinical Psychology
- Positive Psychology
- Legal, Ethical, and Professional Issues.

Books Recommended:

1. Crow, L., & Crow, A. (2000) Educational Psychology, New Delhi: Eurosia Publishing House Ltd.
2. Spiegel, P.K., & Koocher, G.P. (1998), Ethics in Psychology, New York: Oxford University Press
3. Snyder, C.R., & Lopes, S.J. (2000), Handbook of Positive Psychology, New York: Oxford University Press.
4. Compton, W.C. (2005), Introduction to Positive Psychology, USA, Thomson Wadsworth.
5. Debra, L.N. & James Compbell Quick, (2000) Organizational Behaviour (3rd ed), Cincinnat: South Western.
6. Fred Luthans, Alexander, D.S. & Edwin, A. Locke (2000) (Eds), Handbook of Principles of Organizational Behaviour, London: Blackwell.
7. Brannon, L.& Reist, J. (2000), Health Psychology: An Introduction to Behaviour and Health (4th ed.), USA Wadsworth.
8. Donohue, W. & Ferguson, K. (Eds), (2003), Handbook of Professional Ethics for Psychologists; Issues, Questions and Controversies, London: Sage Publications.

9. Meyers, D. (2005), Social Psychology, 8th Ed. McGraw Hill Inc.
10. Cooper, J. & Hogg, M. (2003) Handbook of Social Psychology, Sage Publications
11. Halgin, R.P., Whitbourne, S.K., & Halgin, R. (2004), Abnormal Psychology: Clinical Perspectives on Psychological Disorders, New York: McGraw Hill.
12. Thorndike R.L., & Hage, E.P. (1995), Measurement and Evaluation in Psychology and Education (4th Ed), New York, MacMillan.

PROFESSIONAL ETHICS

Course Description:

Prerequisite: None

Corequisite: None

This course introduce contemporary and controversial ethical issues facing the business community. Topics include moral reasoning, moral dilemmas, law and morality, equity, justice and fairness, ethical standards, and moral development. Upon completion, students should be able to demonstrate an understanding of their moral responsibilities and obligations as members of the workforce and society.

Course Objectives:

At the completion of the course requirements, the student will be able to:

a. Define business ethics
b. Describe the evolution of business ethics
c. Describe major ethical perspectives
d. Understand and apply n ethical decision-making framework
e. Understand social responsibility from several dilemensions
f. Understand how the organization influences ethical decision-making
g. Examine how significant others influence ethical decision-making
h. Develop an effective ethics programme.
i. Understand international business ethics.

Course Outline:

An Overview of Business Ethics: Business Ethics Defined, Social Responsibility, and Business Ethics, The Development of Business Ethics, Why study Business Ethics?, Framework for Studying Business Ethics.

Ethical issues in Business: Foundation of Ethical Conflict, Classifications of Ethical, Issues, Ethical Issues Related to Participants and Functional Areas of Business, Recognizing an Ethical Issue.

Applying Moral Philosophies to Business Ethics: Moral Philosophy Defined, Moral Philosophy Perspectives.

Social Responsibility: The Economic Dimension, The legal Dimension, The Ethical Dimension, the Philanthropic Dimension.

An Ethical Decision-Making Framework: Ethical Issue Intensity, Individual Factors: Stages of Cognitive Moral Development, Corporate Culture, Significant others, Opportunity, Business Ethics Evaluations and Intentions, Using the Ethical Decision-Making Framework to Improve Ethical Decisions.

How the Organization Influences Ethical Decision Making: Organizational Structure and Business Ethics, the role of Corporate Culture in Ethical Decision-Making, Group Dimensions of Organizational Structure and Culture, Implications of Organizational Relationships for Ethical Decisions.

The Role of Opportunity and Conflict: Opportunity, Conflict.

Development of an Effective Ethics Programme: An Effective Ethical Compliance, Programme, Codes of Ethics and Compliance Standards, High-Level Manager's Responsibility for Ethical Compliance Programme and the Delegation of Authority, Effective Communication of Ethical Standards, Establishing Systems to Monitor, Audit, and Enforce Ethical Standards, Continuous Improvement of the Ethical Compliance Programme, The Influence of Personal Values in Business Ethics Programmes, The Ethical Compliance Audit.

International Business Ethics: Ethical Perceptions and International Business, Culture As a Factor in Business, Adapting Ethical Systems to a Global Framework: Cultural Relativism, the Multinational Corporation, A universal Set of Ethics, Ethical Issues Around the Globe.

Text Books:

- Ferrell, O.C., and Fraedrich, John, Ethical Decision Making and Cases, New York: Houghton Mifflin.

ORGANIZATIONAL BEHAVIOUR 3 Credit Hrs

- Introduction to Organizational Behaviour
  - Organizational Disciplines and topics
  - Psychological Perspective
  - Social-Psychological Perspectives
- Structure and Control in Organization
  - Introduction
  - Bureaucracy
  - Managerial Work
  - Contingency theory
  - Organizational Design
- Individual and Work Learning
  - Learning Theories
  - Learning and Work
- Stress
  - Types of Stress and Work
  - Occupational Stress Management
- Individual Differences
  - Personality and its factors
  - Personality dimensions and social learning
  - Intelligence
- Motivation and Job Satisfaction
  - Needs at Work
  - Theories of Motivation and job satisfaction
  - Correlates of Job satisfaction
  - Correlates of Job satisfaction
- Group and Work
  - Social Interaction
  - Dramaturgy and impression Management
  - Social Skill
- Group and Inter group Behaviour
  - Group Structure & Norms
  - Group Processes
  - How throne Studies
- Leadership
  - Leadership as an attribute
  - Leadership Style
- Patterns of Work
  - Work-the classical approach
  - Marx, Weber, & The critique of labor
  - Foucault & Disciplinary Power

- Conflict and Consent in Work
  - The labor Process debate
  - Work place control and resistance
  - Industrial conflict and industrial relations
- Organizational culture
  - Organizational culture and strategic management
  - Exploring organizational culture
  - Evaluating concept of culture

Books Recommended:

1. Finchan, R., & Rhodes, P. (2003), Principles of Organizational Behaviour, 3rd Oxford.
2. Noe, R., Hollenbeck, J. Gerhart, B., & Wright, P. (2006), Human Resource Management, 5th ed., McGraw Hill.
3. Newstrom John W. (2007), Organizational Behaviour, (12th Ed), McGraw Hill.
4. Luthan Fred, (2005), Organizational Behaviour, McGraw Hill Inc.
5. Robins, Stephen, (2005), Organizational Behaviour, McGraw Hill Inc.

INTRODUCTION TO SOCIOLOGY 3 Credit Hrs

- The Nature of Sociology
  - The study of social life
  - Exploring the global village
  - Sociology as a science
  - The Sociological imagination
  - The development of Sociology
  - Pioneers of Sociology
  - Nature, scope and subject matter of Sociology
  - Brief historical development of Sociology
  - Society and community
  - Relationship with other social sciences
  - Social Interaction Processes
- Social groups
  - Definition and functions
  - Types of social groups
- Social institutions
  - Definition
  - Structure and function of social institutions
  - Inter-relationships among various social institutions
- Culture and related concepts
  - Definition and aspects of culture
  - Elements of culture
  - Organization of culture
  - Other concepts, cultural relativism, sub cultures, ethnocentrism, culture lag
- Socialization and personality
  - Role and status
  - Socialization
  - Culture and personality
- Deviance and social control
  - Definition and types of deviance
  - Juvenile delinquency
  - Formal and information methods of social control
- Social stratification
  - Approach to study social stratification
  - Caste class and race as basics of social stratification
- Major perspectives in Sociology
  - Functionalist perspective
  - Conflict perspective
  - Interactionstic perspective

- Social Control and deviance
  - Agencies of social control
- Social stratification
  - Determinants of social stratification
  - Social mobility, types and definition
  - Dynamics of social mobility
- Concept of social movement
  - Theories of social movement
  - Social and cultural change
- Social and cultural change
  - Definition of social change
  - Dynamics of social change
  - Impact of globalization on society and culture
  - Resistance to change
- Collective behaviour
  - Definition
  - Characteristics
  - Causes
  - Types
  - Social movements
  - Mob and crowd behaviour

Books Recommended

1. Neulreck, Kenneth, J. 2005, Sociology: Diversity, Conflict and Change, Boston
2. Barnard, Andy. 2004. Sociology, Cambridge University Press
3. Giddens, Anthony, 2004, Sociology 4th edition, Cambridge Polity Press
4. Albrow, Martin, 2003, Sociology, London Routledge.
5. Richard, T. Schaefer, 2003, Sociology5th edition, McGraw Hill College
6. Kendall, Diana, 2004. Sociology in our Times, 4th ed, Wadsworth
7. Tyler Melissa, Wallace Claire & Abbott Pamela, 2005, An Introduction to Sociology, 3rd ed. Routledge.

CRITICAL THINKING 3 Credit Hrs

- The Power of Critical Thinking
  - Claims and Reasons
  - Reasons and Arguments
  - Arguments in the Rough
- The Environment of Critical Thinking
  - Perils of Haunted Mind
  - Self and the Power of the Group
  - Subjective and Social Relativism
  - Skepticism
- Making Sense of Arguments
  - Arguments Basics
  - Patterns
  - Diagramming Arguments
  - Assessing Long Arguments
- Reasons for Belief and Doubt
  - Conflict Experts and Evidence
  - Personal Experience
  - Fooling Ourselves
  - Claims in the News
- Faulty Reasoning
  - Irrelevant Premises
  - Genetic Fallacy, Composition, Division
  - Appeal to the Person, Equivocation, Appeal to Popularity
  - Appeal to Tradition, Appeal to Ignorance, Appeal to Emotion
  - Red Herring, Straw Man
- Unacceptable Premises
  - Begging the Question, False Dilemma
  - Slippery Slope, Hasty Generalization
  - Faulty Analogy
- Deductive Reasoning: Propositional Logic
  - Connectives and Truth Values
  - Conjunction, Disjunction, Negation
  - Conditional, Checking for Validity
  - Simple Arguments, Tricky Arguments
  - Streamlined Evaluation
- Deductive Reasoning: Categorical Logic
  - Statements and Classes
  - Translations and Standard Form
  - Terms, Quantifiers
  - Diagramming Categorical Statements
  - Sizing up Categorical Syllogisms
- Inductive Reasons
  - Enumerative Induction
  - Sample Size, Representativeness, Opinion Polls

    - Analogical Induction
    - Casual Arguments, Testing for Causes
    - Casual Confusions
- Inference to the Best Explanation
    - Explanations and Inference
    - Theories and Consistency
    - Theories and Criteria
    - Testability, Fruitfulness, Scope, Simplicity
    - Conservatism
- Judging Scientific Theories
    - Science and Not Science
    - The Scientific method, Testing Scientific Theories
    - Judging Scientific Theories
    - Copernicus versus Ptolemy, Evolution Versus Creationism
    - Science and Weird Theories
    - Making Weird Mistakes
    - Leaping to the Weirdest Theory, Mixing What Seems with What is
    - Misunderstanding the Possibilities
    - Judging Weird Theories
    - Crop Circles, Talking with the Dead

BOOKS RECOMMENDED

1. Vaughn Lewis, 2005, The Power of Critical Thinking, Oxford University Press.
2. Paulsen David W., Cederblom Jerry:2000, Critical Reasoning, Wadsworth
3. Restall Greg. 2005, Logic: An Introduction, Routledge

INTRODUCTION TO PHILOSOPY 3 Credit Hrs

- Definition and Nature of Philosophy
- Theory of Knowledge
    - Opinion and Knowledge
    - Plato, the Republic Selection
    - Knowledge through Reason
    - Descartes Meditation on First Philosophy
    - Knowledge through Experience
    - Hume an Inquiry concerning Human Understanding (Selection)
    - Experience Structured by the Mind
    - Kant Critique of Pure Reason (Selection
    - Knowing and Doing
    - James Pragmatism (Selection)
    - Knowledge and Emotion
    - Jaggar Love and Knowledge (Selection)

- Philosophy of Religion
  - Proving that Existence of God
  - Anselm, Aquinas, Paley, Dawkins (Selection)
  - Justifying Religious Beliefs
  - Pascal Pensees (Selection)
  - James The will to Believe Selection
  - Freud the Future of An Illusion (Selection)
  - Confronting the Problems of Evil
  - Mackie Evil and Omnipotence (Complete)
  - Hick Philosophy of Religion (Selection)
- Metaphysics
  - Idealism and Materialism
  - Berkeley Three Dialogues Between Hylas and Pholonous (Selection)
  - Armstrong Naturalism, Materialism and First Philosophy (Selection)
  - The Mid-Body Problem
  - Descartes Meditations on First Philosophy (Selection)
  - O'Hear Introduction to the Philosophy of Science (Selection)
  - Dennett The Origins of Selves (Complete)
  - Pali Canon (Selection)
  - Penelhum Religion and Rationality (Selection)
- Freedom to Choose
  - Libertarianism
  - James The Dilemma of Determinism (Selection)
  - Taylor Metaphysics (Selection)
  - Determinism
  - Hospers Meaning and Free Will (Selection)
  - Skinner Walden Two (Selection)
  - Compatibilism
  - Stace Religion and the Modern Mind (Selection)
  - Radhakrishnan Indian Philosophy (Selection)
- Ethics
  - Fulfilling Human Nature
  - Aristotle Nicomachean Ethics (selection)
  - Loving God
  - Augustine The Morals of the Catholic Church and the City of God (Selection)
  - Following Natural Law
  - Aquinas Summa Theologiae (Selection)
  - Doing One's Duty
  - Kant Fundamental Principles of the Metaphysics of Morals (Selection)
  - Maximizing Utility
  - Mill Utilitarianism (Selection)
  - Turning Values of Upside Down
  - Nietzsche Human, All too Human and Beyond Good and Evil (Selection)
  - Creating Ourselves

- Sartre Existentialism is a Humanism (Selection)
- Hearing the Feminine Voice
- Gilligan In a Different Voice (Selection)
- Baier What do Women Want in a Moral Theory (Selection)

- Political and Social Philosophy
  - The State as Natural
  - Plato the Republic (Selection)
  - Aristotle Politics (Selection)
  - The State as a Social Contract
  - Hobbes Philosophical Rudiments Concerning Government and Society (Selection)
  - Locke the Second Treatise of Government (Selection)
  - Liberty of the Individual
  - Mill On Liberty (Selection)
  - Alienation in Capitalism
  - Marx Economic and Philosophic Manuscripts of 1844 (Selection)
  - Justice and Social Trust
  - Rawls A Theory of Justice (Selection)
  - Nozick Anarchy, State, and Utopia (Selection)
  - Held Rights and Goods (Selection)
  - Women in Society
  - Wollstonecraft A Vindication of the Rights of Women (Selection)
  - De Behaviour The Second Sex (Selection)
  - The Value of Philosophy
  - Russel The Problems of Philosophy (Selection)
  - Midgley Philosophical Plumbing (Selection)

BOOKS RECOMMENDED

1. Abel Donald C., Stumpf Samuel Enoch, 2002. Elements of Philosophy: An Introduction, 4th Ed. McGraw Hill.
2. Scruton Roger, 2001. A short History of Modern Philosophy, 2nd ed. Routledge.

MANAGEMENT COURSES

ENTREPRENEURSHIP

Course Objective:

Entrepreneurship is an important component in the process of economic development. The purpose of this course is to analyse the theories of entrepreneurship and to go for case studies of successful entrepreneurs.

Course Contents:

Introduction: The concept of entrepreneurship, The economist view of entrepreneurship, The sociologist view, Behavioural approach, Entrepreneurship and Management

The Practice of Entrepreneurship: The process of entrepreneurship, Entrepreneurial Management, The entrepreneurial business, Entrepreneurship in service institutions, The new venture

Entrepreneurship and Innovation: The innovation concepts, Importance of innovation for entrepreneurship, Sources of innovative opportunities, The innovation process, Risks involved in innovation

Developing Entrepreneur: Entrepreneurial profile, Trait approach to understanding entrepreneurship, Factors influencing entrepreneurship, The environment, Socio cultural factors, Support systems

Entrepreneurship Organization: Team work, Networking organization, Motivation and compensation, Value system

Entrepreneurship and SMES: Defining SMEs, Scope of SMEs, Entrepreneurial, managers of SME, Financial and marketing problems of SMEs

Entrepreneurial Marketing: Framework for developing entrepreneurial marketing, Devising entrepreneurial marketing plan, Entrepreneurial marketing strategies, Product quality and design

Entrepreneurship and Economic Development: Role of entrepreneur in the economic development generation of services, Employment creation and training, Ideas, knowledge and skill development, The Japanese experience

Case Studies of Successful Entrepreneurs

Text Books:

1. Paul Burns and Jim Dew Hurst: Small Business and Entrepreneurship
2. P.N. Singh: Entrepreneurship fo0r Economic Growth
3. Peter F. Drucker: Innovation and Entrepreneurship Peter F. Drucker
4. John B. Miner: Entrepreneurial Success

PRINCIPLES OF MANAGEMENT

Course Objectives:

This is a rudimentary course for the students of business administration. The focus of attention will be given to learning fundamental principles of management and of managing people and organization in a historical as well as contemporary world. Students are expected to develop analytical and conceptual framework of how people are managed in small, medium and large public and private national and international organizations.

Course Contents:

- Introduction, overview and scope of discipline
- The evolution and emergence of management thought
- Management functions
- Planning concepts, objectives, strategies and policies
- Decision making
- Organizing; departmentalization, line/staff authority, commitments and group decision making
- Staffing: principles of selection, performance, career planning
- Leading: Motivation, leadership, communication
- Controlling: the system and process and techniques of controlling
- Management and Society: future perspective

Text Books:

1. Stephen P. Robins, Mary Coulter: Management
2. H. Koontz Odonnel and H. Weihrich: Management
3. Mc Farland: Management: Foundation and Practice
4. Robert M. Fulmer: The New Management.