CURRICULUM

OF

BS/MS

ENVIRONMENTAL ENGINEERING

(Revised 2017)

HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

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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.

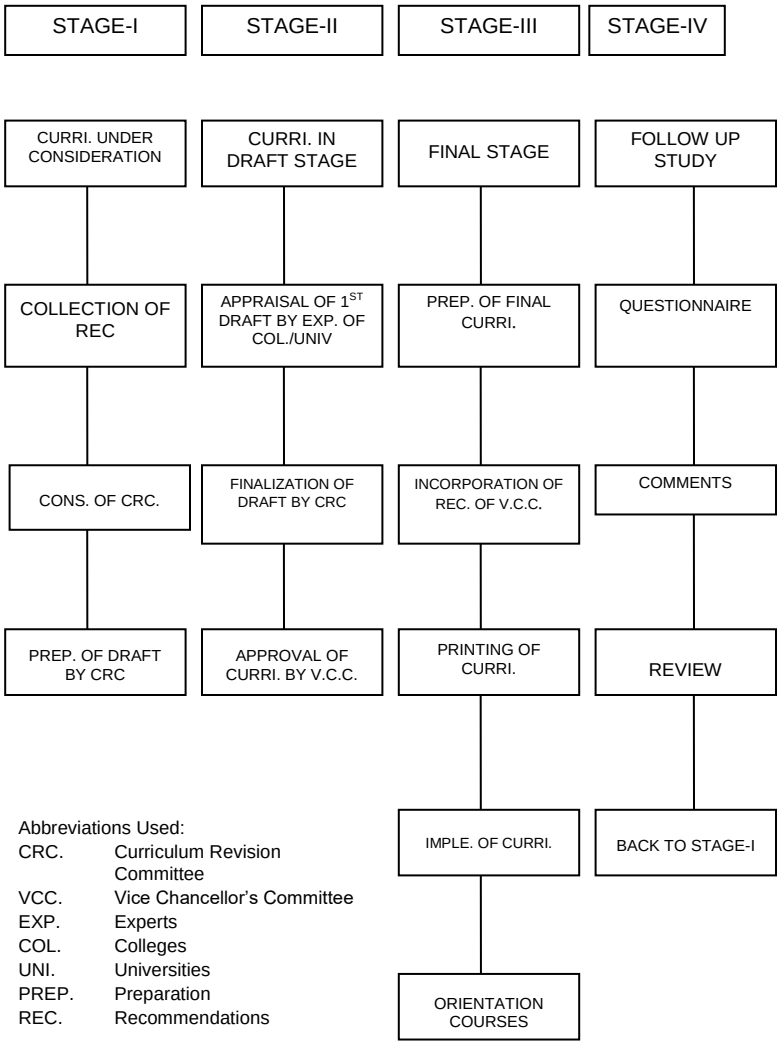
In order to impart quality education which is at par with indigenous needs and international standards, HEC NCRCs have developed unified framework/ templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture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

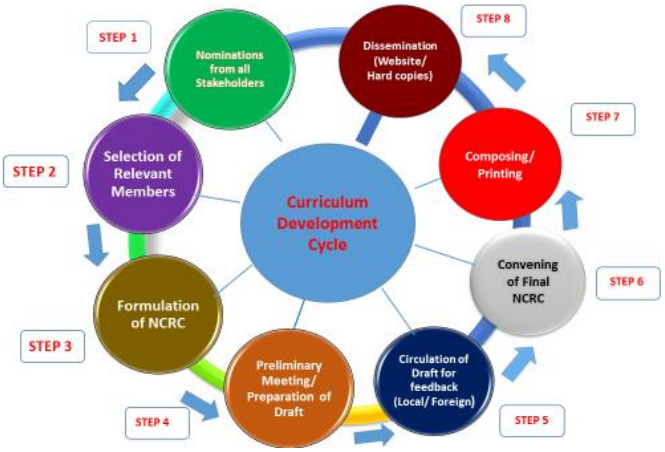
CURRICULUM DEVELOPMENT PROCESS



Abbreviations Used:

CRC.	Curriculum Revision Committee
VCC.	Vice Chancellor's Committee
EXP.	Experts
COL.	Colleges
UNI.	Universities
PREP.	Preparation
REC.	Recommendations

CURRICULUM DEVELOPMENT CYCLE



INTRODUCTION

The final meeting of HEC National Curriculum Revision Committee (NCRC) in the discipline of Environmental Engineering was held from May 10-12, 2017, (03 days) at the Higher Education Commission (HEC), Regional Centre Peshawar. The aim was to finalize the preliminary draft, prepared during first meeting held from February 07-09, 2017. Mr. Riaz-ul-Haque, Assistant Director, Academics Division, HEC acted as Coordinator of the meeting. Following honourable members attended the meeting:

Sr. No	Name & Address	Status
1.	Dr. Farhat Abbas, Professor/Dean, Faculty of Engineering, Department of Environmental Sciences & Engineering, Government College University, Faisalabad.	**Convener**
2.	Dr. Qaisar Mahmood (TI) Associate Professor, Department of Environmental Engineering, COMSATS Institute of Information Technology, Abbottabad.	**Secretary**
3.	Dr. Khan Muhammad Brohi, Director / Professor, Institute of Environmental Engineering & Management, Mehran University of Engineering & Technology, Jamshoro	**Member**
4.	Dr. Taj Ali Khan Professor/Chairman, Department of Agricultural Engineering, University of Engineering & Technology, Peshawar.	**Member**
5.	Dr. Daulat Khan, Professor, Department of Agricultural Engineering, University of Engineering & Technology, Peshawar.	**Member**
6.	Dr. Sajid Rashid Ahmed, Professor/Principal, College of Earth & Environmental Sciences, University of the Punjab, Lahore.	**Member**
7.	Dr. Asif Ahmed Shaikh, Professor / Chairman, Department of Environmental Engg,	**Member**

	NED University of Engineering & Tech, University Road, Karachi.	
8.	Dr. Naseem Irfan Professor / Dy. Chief Engineer, Department of Nuclear Engineering, Pakistan Institute of Engineering & Applied Sciences, P. O Nilore, Islamabad.	**Member**
9.	Engr. Dr. Nasir Mahmood Khan Additional Registrar (Accreditation) Pakistan Engineering Council HQ, Ataturk Avenue, G-5/2, Islamabad	**Member**
10.	Dr. Naeem Ejaz Associate Professor, Department of Environmental Engineering, University of Engineering & Technology, Taxila.	**Member**
11.	Engr. Dr. Sher Jamal Khan Associate Professor Institute of Environmental Sciences & Engineering (IESE), National University of Science & Technology, Islamabad.	**Member**
12.	Dr. Sheeraz Ahmed Memon Associate Professor/Director, Institute of Environmental Engineering & Management, Mehran University of Engineering & Technology, Jamshoro	**Member**
13.	Dr. Muhammad Daud Khan Assistant Professor, Department of Biotechnology & Genetics Engineering, Kohat University of Science & Technology, Kohat,	**Member**
14.	Engr. Dr. Naeem Shahzad Assistant Professor, Department of Water Resource Engineering, Military College of Engineering, Risalpur.	**Member**
15.	Engr. Khurram Sheraz Assistant Professor, Department of Agricultural Engineering, University of Engineering & Technology, Peshawar.	**Member**
16.	Mr. Riaz-Ul-Haque, Assistant Director (Curriculum),	**Coordinator**

	Higher Education Commission, Sector H-9, Islamabad.	

The Following members attended the Preliminary meeting but could not attend the Final meeting due to personal engagements:

S.No.	Name & Institution	Status
1.	Prof. Dr. Badar Munir Khan Ghauri Department of Remote Sensing & GIS, Institute of Space Technology, SUPARCO HQ, Karachi	Member
2.	Dr. Bushra Khan Chairperson / Associate Professor, Department of Environmental Sciences, University of Peshawar, Peshawar.	Member
3.	Engr. Prof. Dr. Zahir-ud-Din Khan Institute of Environmental Engineering & Research, UET, Lahore. (Nominee of PEC)	Member
4. 3	Dr. Arjumand Z. Zaidi Senior Research Fellow US Pakistan Centers for Advanced Studies in Water USPCASW, Mehran University of Engineering & Technology, Jamshoro	Member

The meeting started with recitation from the Holy Quran by Prof. Taj Ali Khan. Mr. Riaz-ul-Haque, Assistant Director, Academics Division, HEC, Islamabad welcomed the participants. All the participants introduced themselves highlighting their qualification, experience and area of expertise within the discipline of Environmental Engineering.

Prof. Dr. Farhat Abbas, Dean, Faculty of Engineering, Department of Environmental Sciences & Engineering, Government College University, Faisalabad and Dr. Qaisar Mahmood (TI) Associate Professor, Department of Environmental Engineering, COMSATS Institute of Information Technology, Abbottabad continued to perform as Convener and Secretary of the final meeting, respectively.

Mr. Riaz-ul-Haque presented the agenda and objectives of the 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/programme, 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/updating the curricula. The template was unanimously accepted to be followed.

In the next session Prof. Dr. Farhat Abbss, Convener opened the discussion on the nomenclature of the discipline, vision, mission, objectives of the programmes, Programme Learning Outcomes (PLOs), methods of instruction and learning environment, assessment and operational framework. After long deliberation, the committee finalized the above said segments of the curriculum. Similarly, framework/scheme of studies of undergraduate 4-years programme for Environmental Engineering was discussed keeping in view the duration of the programme, 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. 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 were 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 learning outcomes, updating list of contents, adding teaching-learning methods and assessment, and updating bibliography/ references/ suggested books.

On the second day, the task assigned to the groups was displayed and the addition/deletion and revision of the courses were discussed. After thorough deliberation, draft curriculum of the Bachelor of Environmental Engineering was finalized.

On the third day, the courses of Master in Environmental Engineering was reviewed and after thorough discussion, the courses were finalized. In the end, Mr. Riaz-Ul-Haque thanked the Convener, Secretary and all members of the Committee for sparing their precious time and for their contribution to finalize the revision process 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 Environmental Engineering. Prof. Dr. Farhat Abbas also thanked the Secretary and members of NCRC 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, Peshawar for making arrangements to facilitate the committee and their accommodation. The meeting ended with a vote of thanks to and from the Chair.

VISION

Ever increasing world population and the resultant expansion of anthropogenic activities demand engineering talent to devise sustainable development procedures. This is possible through promoting Environmental Engineering that is multi-disciplinary in nature; combining the basic principles of Sciences and Engineering and a brand of creative design, invention and innovation supported by the use of advanced techniques and engineering technologies.

MISSION STATEMENT

Engineering disciplines play a vital role in addressing the various challenges facing our societies worldwide. Among others, the major issues include; clean air & water, natural resource management and recovery in the context of climate change, tackling the coupled issues of energy, natural and man-made disaster mitigation, environmental protection, public health and safety. Producing competent Environmental Engineers to effectively delivering real products and services of benefit to society, especially in the developing world, is a responsibility of universities/DAIs. The Environmental Engineering Curriculum is designed to provide necessary knowledge, critical thinking, and ethical values to the graduates for meeting the aforementioned large-scale 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
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 Environmental Engineering will achieve the following PEOs; **PEO-01**: Apply engineering knowledge to identify and address the technical and societal problems; **PEO-02**: Enhance students' intellectual and analytical abilities in taking initiative and/or developing innovative ideas for technological and professional growth in the field of environmental engineering; **PLO-03**: Work effectively as a team member or lead multidisciplinary teams while determining / demonstrating the interpersonal and management skills and ethical responsibilities.

Program Learning Outcomes (PLOs)

Program outcomes are the narrower statements that describe what students are expected to know and can 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 (PLOs) of Environmental 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 Environmental Engineering programs are based on Course Learning Outcomes (CLOs) that necessitate that upon successful completion of the course, the student will i) **Recognize** the measurement systems and **describe** the concept of techniques, accuracy, precision, and errors in all measuring instruments, ii) **Implement** procedures with the instruments used to measure different parameters; e.g., pressure, temperature, force, motion, torque, flow etc., iii) **Show** the fundamentals of measurement systems by designing the protocol and necessary tools for this task, iv) **Operate** measuring instrument and **follow** signal of the instrument, and v) **Demonstrate** the working principles of instruments and techniques for a particular application. The underline verbs would be used in Question papers as it is. With the help of this linkage we can find out achievement report of each CLO in final results.

RATIONALE

The Curriculum of Environmental 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 Environmental 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 exam and the remaining 50% of the marks accordingly distributed for Mid exam and semester work (including quiz, complex engineering problems, 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 Demonstrating skills of students to perform experiments, iii) introduction of open-ended labs to solve complex engineering problems, and iv) Viva Voce. The lab part of the course may also be assessed, covering the psychomotor (skills) and affective (attitude) domains, as a total of 100 to be converted to the ratio of actual lab score, for the number of specified credit hours. The following table proposes typical calculations for scores/marks for a course.

Activity	Proportional Score
Mid	25-30% of the total theory part
Sessional (quiz, complex engineering problems through class projects and assignments, presentations etc...)	20-25% of the total theory part
Lab	100% of the total lab part
Final	50% of the total theory part
Total	100%; 40, 60, and 80 for 2, 3 and 4 credit hours courses, respectively.

Field visits and their reports may be the part of sessional marks wherever deem fit.

SCOPE

The scope of Environmental 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 Environmental Engineering. The role for Government-Industry-Academia linkage to address problems facing industry and their indigenous solutions is also in the scope of this curriculum.

INTAKE/ADMISSION CRITERIA

Engineering Education Regulations of Pakistan Engineering Council should be adhered to for admission criteria and intake policy. Generally, the following criteria should be observed as: i) For Bachelor of Environmental Engineering: Intermediate Pre-Engineering or equivalent, securing at least 60% marks and ii) Admission criteria for Master of Environmental Engineering: Bachelor in the relevant Engineering disciplines accredited by the Pakistan Engineering Council.

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, 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.

FRAMEWORK FOR BACHELOR IN ENVIRONMENTAL ENGINEERING

Duration:	4 years
Semester:	8
Number of weeks per semester:	18 (16 for teaching and 2 for examination)
Total number of Credit Hours (CH):	130 (minimum)
Number of CH per semester:	13 - 18
Engineering Domain Courses:	65 - 70%
Non-Engineering Domain Courses:	30 - 35%
Number of Contact Hours:	199

SCHEME OF STUDIES FOR BS/BE ENVIRONMENTAL ENGINEERING

Non-Engineering Domain									
Knowledge Area	**Subject Area**	**Name of Course**	**Lec CH**	**Lab CH**	**CH**	**Total Courses**	**Total Credits**	**% Area**	**% over all**
Humanities	English	Communication Skills	3	0	3	2	5	12.50	4.3
		Technical Writing & Presentation Skills	2	0	2				
	Culture	Islamic Studies	2	0	2	2	4	10.00	4.3
		Pakistan Studies	2	0	2				
	Social Sciences	Environment & Anthropology Sociology of development Env. & Human Interaction Psychology Sustainable Urban Planning	2	0	2	1	2	5.00	2.1
			11	**0**	**11**	**5**	**11**	27.50	10.7
Management Sciences		Engineering Economics	2	0	2	3	6	15.00	6.52
		Project Planning & Management	2	0	2				
		Entrepreneurship	2	0	2				
			6	**0**	**6**	**3**	**6**	15.00	6.52

Natural Sciences	Math	Engineering Calculus	3	0	3	4	12	30.00	8.70
		Linear Algebra & Ordinary Differential Equations	3	0	3				
		Numerical Analysis	3	0	3				
		Probability and Statistical Analysis	3	0	3				
	Physics	Environmental Physics	2	0	2	1	2	5.00	2.1
	Chemistry	Environmental Chemistry	3	0	3	1	3	7.5	2.1
	Biology and Microbiology	Introduction to Microbiology,	3	0	3	2	6	15.00	4.3
		Environmental Microbiology	2	1	3				
Sub-Total-I			**39**	**1**	**40**	**16**	**40**	**100**	**35**

Engineering Domain									
Knowledge Area	**Subject Area**	**Name of Course**	**Lec CH**	**Lab CH**	**Total CH**	**Total Courses**	**Total Credits**	**% Area**	**% overall**
Computing	**Fundamental Programing**	Computer Aided Learning	2	1	3	2	6	4.5	4.3
		Introduction to Computer Programming	2	1	3				
			4	**2**	**6**	**2**	**6**	**4.5**	**4.3**
Engineering Foundation		Surveying and Leveling	2	1	3	9	29	22.14	19.56
		Engineering Mechanics	2	1	3				
		GIS	2	1	3				
		Remote Sensing	2	1	3				
		Fluid Mechanics	3	1	4				
		Soil Mechanics	3	1	4				
		Engineering Drawing & CAD	1	2	3				
		Introduction to Environmental Engineering	3	0	3				
		Elective	3	0	3				
			21	**8**	**29**	**9**	**29**	22.14	19.56
Core (Breadth)		Water Treatment	2	1	3	10	31	23.66	21.73
		Wastewater Engineering	2	1	3				

		Water Supply and Wastewater Collection/Water Pollution Control/Ground Water Pollution Control	2	1	3				
		Energy Conservation and management	3	0	3				
		Industrial and Hazardous Waste Management	3	0	3				
		Hydrology	3	0	3				
		Air & Noise Pollution Control	3	1	4				
		Solid Waste Engineering & Management	3	1	4				
		Environmental Laws and Policies	2	0	2				
		Elective	3	0	3				
			26	**5**	**31**	**10**	**31**	**23.66**	**21.27**
Major Based		Environmental Health &Safety	3	0	3	5	14	11.45	10.86
Core (Depth)		Integrated Water Resources Management	3	0	3				
		Environmental Impact Assessment	3	0	3				

		Cleaner Production Techniques	3	0	3				
		Ecological Management	2	0	2				
			14	**0**	**14**	**5**	**14**	**11.45**	**10.86**
Inter-disciplinary Engineering Breadth (Electives)		Professional Ethics	2	0	2	2	5	3.82	4.34
		Thermodynamics	2	1	3				
			4	**1**	**5**	**2**	**5**	**3.82**	**4.34**
Final Year Project		Final Year Project-I	0	3	3	2	6	6.67	5.00
		Final Year Project-II	0	3	3				
			0	**6**	**6**	**2**	**6**	**4.58**	**4.34**
Internship		Optional	**0**	**0**	**0**	**0**	**0**	-	-
Sub-Total-II			**69**	**22**	**91**	**32**	**91**	**100**	**65**
Grant Total (I+II)			**108**	**23**	**131**	**46**	**131**		**100**

NOTE:
Universities have the option to add course of 3 credit hours in the engineering foundation and breadth domain.

SCHEME OF STUDIES (Semester wise)
Bachelor in Environmental Engineering

Semester-1

Course No.	Course Title	Lec.-CH	Lab-CH	Total- CH
1	Communication Skills	3	0	3
2	Linear Algebra and Ordinary Differential Equation	3	0	3
3	Introduction to Environmental Engineering	3	0	3
4	Computer Aided Learning / Fundamentals of ICT	2	1	3
5	Islamic Studies	2	0	2
6	Environmental Physics	2	0	2
	Total	15	1	16

Semester-2

Course No.	Course Title	Lec.- CH	Lab - CH	Total- CH
1	Engineering Calculus	3	0	3
2	Environmental Chemistry	3	0	3
3	Engineering Mechanics	2	1	3
4	Pakistan Studies	2	0	2
5	Introduction to Computer Programing	2	1	3
6	Surveying and Leveling	2	1	3
	Total	14	3	17

Semester-3

Course No.	Course Title	Lec. -CH	Lab - CH	Total – CH
1	Introduction to Microbiology	3	0	3
2	Environment and Anthropology/ Sustainable Urban Planning	2	0	2
3	Probability and Statistical Analysis	3	0	3

4	Fluid Mechanics	3	1	4
5	Engineering Drawing & CAD (Computer Aided Design)	1	2	3
6	Engineering Economics	2	0	2
	Total	14	3	17

Semester-4

Course No.	Course Title	Lec.- CH	Lab - CH	Total – CH
1	Water Supply and Wastewater Collection	2	1	3
2	Environmental Microbiology	2	1	3
3	Ecological Management	2	0	2
4	Numerical Analysis	3	0	3
5	Hydrology	3	0	3
6	Thermodynamics	2	1	3
	Total	14	3	17

Supervised Internship (To be carried out after 2 years of the study period with total duration of 4 to 8 weeks as an independent study or with a consultancy group).

Semester-5

Course No.	Course Title	Lec. - CH	Lab - CH	Total- CH
1	Water Treatment	2	1	3
2	Soil Mechanics	3	1	4
3	Professional Ethics	2	0	2
4	Solid Waste Engineering & Management	3	1	4
5	Geographical Information System	2	1	3
	Total	12	4	16

Semester-6

Course No.	Course Title	Lec.- CH	Lab - CH	Total – CH
1	Project Planning & Management	2	0	2
2	Wastewater Engineering	2	1	3

3	Environmental Impact Assessment	3	0	3
4	Air & Noise Pollution Control	3	1	4
5	Remote Sensing	2	1	3
6	Environmental Health & Safety	3	0	3
	Total	15	3	18

Semester-7

Course No.	Course Title	Lec. - CH	Lab - CH	Total –CH
1	Integrated Water Resources Management	3	0	3
2	Elective Course I	3	0	3
3	Technical Writing and Presentation Skills	2	0	2
4	Environmental Laws and Policies	2	0	2
5	Industrial and Hazardous Waste Management	3	0	3
6	Final Year Design Project – I	0	3	3
	Total	13	3	16

Semester-8

Course No.	Course Title	Lec. - CH	Lab - CH	Total – CH
1	Cleaner Production Techniques	3	0	3
2	Energy Conservation & Management	3	0	3
3	Entrepreneurship	2	0	2
4	Elective II	3	0	3
5	Final Year Project – II	0	3	3
	Total	11	3	14

Total Credit Hours 131

Elective Course:

- Marine Pollution Control (3-0)
- Environmental Modeling (3-0)

- Climate Change Adaptation and Mitigation (3-0)
- Hazard and Disaster Risk Management (3-0)
- Green Engineering Technologies (3-0)
- Membrane Technology (3-0)
- Environmental Nanotechnology (3-0)
- Natural Resources Management (3-0)

MATRICS OF THE COURSE MAPPING WITH PROGRAM LEARNING OUTCOMES

Course Title	1	2	3	4	5	6	7	8	9	10	11	12
Semester-1												
Communication Skills										√		
Linear Algebra and Ordinary Differential Equation		√		√								
Introduction to Environmental Engineering	√					√						
Computer Aided Learning / Fundamentals of ICT	√											
Islamic Studies								√				√
Environmental Physics	√	√										
Semester-2												
Engineering Calculus		√										
Environmental Chemistry	√	√										
Engineering Mechanics	√	√										
Pakistan Studies						√						
Introduction to Computer Programing				√								
Surveying and Leveling		√		√					√			
Semester-3												
Introduction to Microbiology		√	√	√								
Environment and Anthropology/Sustainable Urban Planning			√	√		√	√					

Probability and Statistical Analysis		√										
Fluid Mechanics	√	√										
Engineering Drawing & CAD	√	√	√		√							
Engineering Economics							√				√	
Semester-4												
Water Supply and Wastewater Collection	√	√			√							
Environmental Microbiology				√								
Ecological Management			√	√		√	√					
Numerical Analysis		√										
Hydrology	√	√										
Thermodynamics	√	√				√						
Semester-5												
Water Treatment	√		√						√			
Professional Ethics						√		√				
Soil Mechanics	√								√			
Solid Waste Engineering & Management			√	√		√						
GIS (Geographical Information System)		√		√	√							
Semester-6												
Project Planning & Management			√	√							√	

Wastewater Engineering	√		√	√			√		√			
Environmental Impact Assessment		√	√			√	√			√		
Air & Noise Pollution Control	√	√							√			
Remote Sensing		√		√	√							
Environmental Health & Safety					√	√		√				
Semester-7												
Integrated Water Resources Management							√					
Elective Course -I												
Technical Writing and Presentation Skills											√	
Environmental Law and Policies		√					√	√				
Industrial and Hazardous Waste Management		√	√	√								
Final Year Project – I		√							√		√	
Semester-8												
Cleaner Production Techniques					√						√	
Energy Conservation & Management	√	√	√								√	
Entrepreneurship										√		√
Elective II												
Final Year Project – II		√	√	√					√	√	√	

DETAIL OF COURSES
Bachelor of Environmental Engineering

SEMESTER 1

COMMUNICATION SKILLS 3(3+0)

Objectives:
- To enable the students to meet their real life communication needs

Course Learning Outcomes (CLOs):
After studying this course, the learners will be able to:-

Sr. No	Course Learning Outcomes	Domain	Taxonomy level	Program Learning Outcome
1				10

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: (Latest editions where possible)
- Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.

- 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).
- 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).
- Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
- Reading and Study Skills by John Langan
- Study Skills by Riachard Yorky.

LINEAR ALGEBRA & ORDINARY DIFFERENTIAL EQUATIONS **3(3+0)**

Objectives:
To make the students aware of the existence, classification, solutions and applications of different types of Differential Equations

Course Learning Outcomes (CLOs):
After studying this course, the learners will be able to:-

Sr. No	Course Learning Outcomes	Domain	Taxonomy level	Program Learning Outcome
1				2
2				4

Contents:
- Introduction and Classification of Differential equation (DE):
- Linear Differential equations. , Classification of DE, Implicit, Explicit and Initial Value Problems.
- Existence of a Unique Solution:
- Analytical Methods to solve First Order DEs; Separable Equation.
- Linear Equations:
- Exact Equation; Methods to make a Non-exact as Exact DE
- Solution by Substitutions:
- Homogeneous DE, Bernoulli's DE, Reduction to Separation of Variable.
- Difference between linear and Non-linear Differential equations. Applications of First Order Linear Des.
- Miscellaneous Problems and Applications.
- Basic Theory of Higher order DEs; Linear DEs. Homogeneous Des.

- Homogeneous linear DEs with constant coefficients.
- Non-Homogeneous linear DEs with constant coefficients, and variable coefficients.
- Variation of Parameters.
- The Laplace Transform:
  Basic Theory and its properties, Inverse Transforms.
- Transforms of Derivatives, Solving DEs,
- Partial Differential Equations (PDEs); Basic Theory, Method of Separation of Variables. Heat equation.
- Wave Equation and vibration problems. Laplace Equations.

Recommended Books: (Latest editions where possible)

Text-Books:

- Textbook: Differential Equations and Boundary Value Problems (6th Edition)
- Author: Dennis G. Zill, Micael R. Cullen
- Publisher: Brooks Cole, Thomson Learning, 2006
- Referred as: Zill

Reference Books: (Latest Editions where possible)

- Differential Equations and Boundary Value Problems (3rd Edition)
- Author: C. Henry Edwards, David E. Penny, 2007
- Publisher: Pearson Education
- Referred as: Penny

INTRODUCTION TO ENVIRONMENTAL ENGINEERING 3 (3+0)
Course Learning Outcomes (CLOs):
After studying this course, the learners will be able to:-

Sr. No	Course Learning Outcomes	Domain	Taxonomy level	Program Learning Outcome
1	**Describe** basic knowledge towards environment and its surrounding	Cognitive	1	1
2	**Understand** fundamental principles, concepts and applications of environmental engineering	Cognitive	2	6

Course Outlines:

- Introduction to environmental engineering
- Identification of the factors affecting the environment.
- The causes and effects of environmental pollution (water, air and land).
- An overview of national environmental problems
- Global environmental issues (acid rain, global warming, ozone depletion and green house gases).
- Point source and non-point source pollution
- Basic understanding of natural resources characteristics, ecology and ecosystems
- Urban planning and sustainable development, definition and inter-relationship between its components.
- Overview of safety and environmental risk assessment

Recommended Books: (Latest editions where possible)

- Mackenzie L. Davis, and Susan J. Masten, Principles of Environmental Engineering and Science, Third Edition, 2002, McGraw-Hill, ISBN: 0073122351
- Mackenzie Davis, and David Cornwell, Introduction to Environmental Engineering, Fifth Edition, 2006, McGraw-Hill, ISBN: 0072424117Tom D. Reynolds, Paul A. Richards, Unit Operations and Processes in Environmental Engineering, Second Edition, 1995, CL-Engineering, ISBN: 0534948847
- Masters, G.M. and W.P. Ela. Introduction to Environmental Engineering and Science, third edition, 2007, published by Pearson Education, ISBN 13: 9789332549760

COMPUTER AIDED LEARNING/FUNDAMENTALS OF ICT 3 (2+1)

Objectives:

Teach the structure, operation, programing, and applications of computers.

Course Learning Outcomes (CLOs):

After studying this course, the learners will be able to:-

Sr. No	Course Learning Outcomes	Domain	Taxonomy level	Program Learning Outcome
1	**Describe** basic knowledge of ICT	Cognitive	1	1

Contents:

- History, classification, basic components,
- CPU, memory, peripheral devices, storage media and devices,
- Physical and logical storage, data organization, file storage,
- Programs and software, system software, application software,
- Operating systems, programing languages, compilation and interpretation,
- Problem specification, algorithms, flow chart, pseudo code,
- Basic programming techniques, data types and declaration, header file and linkage,
- Variables and constants, arrays, input/output,
- Termination, remark, control structures, branching,
- Conditional structures, repetition and loops,
- Basic library functions, social impact of computer age,
- Computers in office, industry and education.

Lab Outline:

- Computation of number system,
- Implementation of Boolean functions,
- Basic machines organization including motherboard,
- Memory, I/O cards, networking devices,
- Use of flow charts, introduction to office tools, overview of different browsers including open-source browsers,
- Introduction to various operating systems, coding, executing and debugging simple programs,
- Implementation of simple control structures,
- Implementation of simple functions, implementation of different function styles.

Recommended Books: (Latest editions where possible)

- Brian Williams and Stacey Sawyer, “Using Information Technology,” Ninth Edition, 2010, McGraw-Hill, ISBN: 0073516775
- William Stallings, “Computer Organization and Architecture: Designing for Performance,” Ninth Edition, 2012, Prentice Hall, ISBN: 013293633X

ISLAMIC STUDIES **2 (2+0)**

Objectives:

- To provide basic information about Islamic Studies and to enhance understanding of the students regarding Islamic civilization
- To enhance the skill of the students for understanding of issues related to faith and religious life.

Course Learning Outcomes (CLOs):
After studying this course, the learners will be able to:-

Sr. No	Course Learning Outcomes	Domain	Taxonomy level	Program Learning Outcome
1			1	1
2			2	12

Contents:

- Introduction to Quranic studies: basic concepts of Quran, history of Quran, Uloom-ul-Quran

INTRODUCTION TO QURANIC STUDIES

- Basic concepts of Quran
- History of Quran
- Uloom-ul -Quran

STUDY OF SELECTED TEXT OF HOLY QURAN

- Verses of Surah Al-Baqra Related to Faith (Verse No-284-286)
- Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
- Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
- Verses of Surah al-Furqan Related to Social Ethics (Verse No. 63-77)
- Verses of Surah Al-Inam Related to Ihkam (Verse No-152-154)

STUDY OF SELECTED TEXT OF HOLY QURAN

- Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No. 6,21,40,56,57,58.)
- Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
- Verses of Surah Al-Saf Related to Tafakar, Tadabar (Verse No-1,14)

SEERAT OF HOLY PROPHET (S.A.W) I

- Life of Muhammad Bin Abdullah (Before Prophet Hood)
- Life of Holy Prophet (S.A.W) in Makkah

- Important lessons derived from the life of Holy Prophet (SAW) in Makkah

SEERAT OF HOLY PROPHET (S.A.W) II

- Life of Holy Prophet (SAW) in Madina
- Important events of life of Holy Prophet (SAW) in Madina
- Important lessons derived from the life of Holy Prophet (SAW) in Madina

INTRODUCTION TO SUNNAH

- Basic concepts of Hadith
- History of Hadith
- Kinds of Hadith
- Uloom–ul-Hadith
- Sunnah & Hadith
- Legal position of Sunnah

SELECTED STUDY FROM TEXT OF HADITH

INTRODUCTION TO ISLAMIC LAW & JURISPRUDENCE

- Basic concepts of Islamic law & jurisprudence
- History & importance of Islamic law & jurisprudence
- Sources of Islamic law & jurisprudence
- Nature of differences in Islamic law
- Islam and sectarianism

ISLAMIC CULTURE & CIVILIZATION

- Basic concepts of Islamic culture & civilization
- Historical development of Islamic culture & civilization
- Characteristics of Islamic culture & civilization
- Islamic culture & civilization and contemporary issues

ISLAM & SCIENCE

- Basic concepts of Islam & science
- Contributions of muslims in the development of science
- Quranic & science

ISLAMIC ECONOMIC SYSTEM

- Basic concepts of Islamic economic system
- Means of distribution of wealth in Islamic economics
- Islamic concept of riba
- Islamic ways of trade & commerce

POLITICAL SYSTEM OF ISLAM

- Basic concepts of Islamic political system
- Islamic concept of sovereignty
- Basic institutions of government in Islam

ISLAMIC HISTORY

- Period of Khlaft-e-Rashida
- Period of Ummayyads
- Period of Abbasids

SOCIAL SYSTEM OF ISLAM

- Basic concepts of social system of Islam
- Elements of family
- Ethical values of Islam

Recommended Books: (Latest editions where possible)

- Hameedullah Muhammad, "Emergence of Islam" , IRI, Islamabad
- Hameedullah Muhammad, "Muslim Conduct of State"
- Hameedullah Muhammad, 'Introduction to Islam
- Mulana Muhammad YousafIslahi,"
- Hussain Hamid Hassan, "An Introduction to the Study of Islamic Law" leaf Publication Islamabad, Pakistan.
- Ahmad Hasan, "Principles of Islamic Jurisprudence" Islamic Research
  Institute, International Islamic University, Islamabad (1993)
- Mir Waliullah, "Muslim Jurisprudence and the Quranic Law of Crimes"
- Islamic Book Service (1982)
- H. S. Bhatia, "Studies in Islamic Law, Religion and Society" Deep & Deep Publications New Delhi (1989)
- Dr. Muhammad Zia-ul-Haq, "Introduction to Al Sharia Al Islamia" Allama Iqbal Open University, Islamabad (2001)

ENVIRONMENTAL PHYSICS **2 (2+0)**

Contact Hours	**Credit Hours**
Theory =32	Theory = 2
Practical =0	Practical = 0
Total =32	**Total = 2**

COURSE LEARNING OUTCOMES:

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

Ser	CLO	Domain	Taxonomy level	PLO
1.	UNDERSTAND how to apply the basic thermodynamics to the human environment, the basic composition, structure and dynamics of the atmosphere,	Cognitive	2	1
2.	DISCUSS specific environmental problems related to physics such as noise pollution, ozone depletion and global warming in the context of an overall understanding of the dynamics of the atmosphere	Cognitive	3	2

Contents:

- Laws of Thermodynamics and the human body,
- Human environment and energy transfers,
- Noise pollution,
- Structure and composition of the atmosphere,
- Ozone in the atmosphere,
- Greenhouse effect,
- Global warming,
- Hydrosphere and hydrologic cycle,
- Water in the atmosphere and clouds,
- Cyclones and anticyclones, global convection and global wind pattern,
- Physics of ground, and
- Energy for living.

Recommended Books: (Latest editions where possible)

- Nigel Mason and Peter Hughes: Introduction to Environmental Physics: Planet Earth, Life and Climate,Taylor and Francis, 2001
- David Halliday, Robert Resnick, and Jearl Walker, “Fundamentals of Physics,” 7th Edition, 2005, John Wiley & Sons, ISBN: 0471465097.
- Arthur Beiser, “Schaum's Outline of Applied Physics,” 4th Edition, 2004, McGraw-Hill, ISBN: 0071426116

SEMESTER 2

ENGINEERING CALCULUS **3 (3+0)**

Objective:
To learn fundamentals of mathematics, calculus and analytical geometry
Course Learning Outcomes (CLOs):
After studying this course, the learners will be able to:-

Sr. No	Course Learning Outcomes	Domain	Taxonomy level	Program Learning Outcome
1	**Describe** basic knowledge towards environment and its surrounding	Cognitive		2

Contents:

- Review of vectors, scalar and vector products, Definition of limit and continuity, techniques of finding limits.
- Complex Numbers: Basic Operations, Graphical Representations, Polar and Exponential Forms of Complex Numbers, De'Moivre's Theorem.
- Functions: Hyperbolic Functions, Hyperbolic and Trigonometric identities and their relationship, Exponential Functions.
- Differentiation: Differentiation and Successive Differentiation and its
- Application to Rate, Speed and Acceleration, Leibritze's Theorem, Equations of Tangents and Normals, Curvature, Radius and Centre of Curvature, Centre of mass.
- Maxima and Minima of Function of One Variable and its Applications, Convexity and Concavity, Points of Inflexion.
- Concept of Infinite Series, Taylor's and Mclaurin's Series and Expansion of Functions.
- Partial Differentiation: Partial Differential Coefficient and Chain Rule, Partial Differentiation of an Implicit Function, Total Differential, Euler's Theorem, Statement of Taylor's Theorem of Two Independent Variable and its Applications.
- Integral Calculus: Standard Integrals, Integration by Substitution, by Partial Fractions and by Parts, Integration of Trigonometric Functions, Definite Integrals and their Properties.
- Co-ordinate Systems in Three Dimensions, Direction Cosines, Plane (Straight Line) and Sphere.

Text/ Recommended Books: (Latest editions where possible)

- Murray Spiegel, Seymour Lipschutz, John Schiller, Dennis Spellman Schaum's series, Complex, Schum's series, 2010, McGraw Hill Publishers, New York, USA.
- Antom, H. Calculus and Analytic Geometry, John Wiley and Sons.
- Talpur, Calculus and Analytic Geometry, Ferozsons
- Yousuf, S. M. Mathematical Methods, Ilmi Kutab Khana
- G. B. Thomas Jr. & MR. L. Finney, Calculus & Analytical Geometry.
- E. W. Swokowski, M. Olinick, D. Pence, Calculus

ENVIRONMENTAL CHEMISTRY **3 (3+0)**

Contact Hours	**Credit Hours**
Theory =48	Theory = 3
Practical =0	Practical = 0
Total =48	**Total = 3**

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	Develop **UNDERSTANDING** of chemistry and its applications in environmental engineering	Cognitive	2	1
2.	**PREPARE** students to deal with chemical principles operation in natural and altered environment.	Cognitive	3	2

Course Outline

1. Introduction to environmental chemistry, its scope, importance and brief history.
2. Basic concepts of various branches of chemistry related to environmental chemistry:
   a. general chemistry,
   b. physical chemistry,
   c. inorganic chemistry,
   d. organic chemistry,
   e. biochemistry,
   f. photochemistry and
   g. colloidal chemistry
   h. nuclear chemistry

i. nanochemistry

3. Basic concepts (Acids and bases: pH diagrams, pH buffers, Precipitation and dissolution, Ion association and dissociation reactions, Redox reactions).
4. Main components of environment (air, water and soil)
5. Air chemistry (important physical and chemical properties of air)
6. Water chemistry (important physical and chemical properties of water)
7. Soil chemistry (important physical and chemical properties of soil).
8. Emerging environmental pollutants
9. Transfer and fate of pollutants in soil, air and water

Recommended Books:

1. Ronald A. Hites, Jonathan D. Raff., 2012. Elements of Environmental Chemistry, John Willey Publishers, USA.
2. Clair N. Sawyer, Perry L. Mc Carly & Geve F Partern, Chemistry for Environmental Engineering and Science. McGraw-Hill, Inc.
3. Harrison R. M., De Mora S. J., Introductory Chemistry for the Environmental Sciences, Cambridge Environmental Series No. 17, Latest Edition, Macmillan Press Ltd.
4. Brimblecombe, P., Jickells T. D., Liss, P. S., An Introduction to Environmental Chemistry, Latest Edition.
5. Stumm, W. and Morgan J., Aquatic Chemistry, Chemical Equilibria and Rates in Natural Waters, Latest Edition, John Wiley and Sons, Inc., ISBN 0-471-51185-4.
6. Stanley E. Manahan. Fundamentals of Environmental Chemistry, 2008, CRC Press

ENGINEERING MECHANICS **3(2-1)**

Contact Hours	**Credit Hours**
Theory =32	Theory =2
Practical =48	Practical=1
Total =80	**Total =3**

Prerequisites

NIL

Course Learning Outcomes:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Recognize** the basic concepts and laws of kinematics and dynamics	Cognitive	1	1
2.	**Analyze** and solve problems in mechanics	Cognitive	2	2

COURSE OUTLINE:

Statics

1. Vectors
- a) Scalars and vectors
- b) Components in two dimensions
- c) Dot products
- d) Cross products

2. Forces
- a) Forces, equilibrium and free-body diagrams
- b) Two-dimensional force systems

3. Systems of Forces and Moments
- a) Two-dimensional description of the moment
- b) The moment vector
- c) Moment of a force about a line
- d) Couples
- e) Equivalent systems

4. Objects In Equilibrium
- a) Two-dimensional applications

5. Centroids
- a) Centroids of areas
- b) Composite areas
- c) Distributed loads

6. Moment of Inertia
- a) Definitions
- b) Parallel-axis theorem
- c) Polar moment of inertia
- d) Radius of gyration

7. Friction
- a) Theory of dry friction
- b) Frictional forces on screw
- c) Frictional forces flat belt

8. Truss
- a) Method of joints
- b) Method of section

Dynamics

1. Rectilinear and curvilinear motion
2. Newton's equation of motion
3. Projectile motion (Derivation & Numerical)
4. Numerical involving linear and angular momentum
5. Numerical involving work-energy principle

TEXT BOOKS

Engineering Mechanics – Statics by R.C. Hibbeler (*13th edition*), 2013
Engineering Mechanics – Dynamics by R.C. Hibbeler (*13th edition*), 2013

PAKISTAN STUDIES **2 (2+0)**

Objectives:

- To develop vision of Historical Perspective, Government, Politics, Contemporary Pakistan, ideological background of Pakistan.
- To study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

Course Learning Outcomes (CLOs):

After studying this course, the learners will be able to:-

S.No	Course Learning Outcomes	Domain	Taxonomy level	Program Learning Outcome
1	**Understand** fundamental principles, concepts and applications of environmental engineering	Cognitive	2	6

Contents:

- Historical Perspective: ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah.
- Factors leading to Muslim separatism
- People and Land: Indus civilization, Muslim advent, location and Geo-physical features.
- 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

- 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

Recommended Books: (Latest editions where possible)

- Akbar, S. Zaidi. *Issue in Pakistan's Economy.* Karachi: Oxford University Press, 2000.
- Amin, Tahir. *Ethno-National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.
- Ziring, Lawrence. *Enigma of Political Development.* Kent England: Wm Dawson& sons Ltd, 1980.
- Afzal, M. Rafique. *Political Parties in Pakistan,* Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
- Haq, Noor ul. *Making of Pakistan: The Military Perspective.* Islamabad: National Commission on Historical and Cultural Research, 1993.

INTRODUCTION TO COMPUTER PROGRAMING 3 (1+2)

Objectives:

- To learn computer languages,
- To enhance skills of computer programming applications.
- **Course Learning Outcomes (CLOs):**
- After studying this course, the learners will be able to:-

S.No	Course Learning Outcomes	Domain	Taxonomy level	Program Learning Outcome
1	**Describe** basic knowledge towards environment and its surrounding	Cognitive	1	4

Contents:

- Introduction to computer programing, Programme structure and flow charts.

- Programing Fundamentals: Arithmetic operations and functions, input/output statements,
- Decision making statements and loop functions and subroutines.
- Data and Data Files.
- Computer Languages: Fundamentals of FORTRAN, Visual BASIC and/or Visual C++ Programing.
- Applications: Programing of simple and elementary environmental engineering problems.
- Internet: Use of web as an academic tool.

Recommended Books: (Latest editions where possible)

- Gottfried, B. S. Programming with Structured Basics (Schaum Series), First Edition 1992, McGraw-Hill, ISBN: 0070238995
- Steve Holzner and Steven Holzner, C++ Black Book: A Comprehensive Guide to C++ Mastery, 2002, Paraglyph Press, ISBN: 1932111263
- Evangelos Petroutsos, Mastering Visual Basic 6, Second Edition, 1998, Sybex Computer Books Inc. USA, ISBN: 0782122728

SURVEYING AND LEVELING **3(2-1)**

Contact Hours:	**Credit Hours:**
Theory =32	Theory =**2**
Practical = 48	Practical =**1**
Total = 80	Total = **3**

Course learning outcomes:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**ACQUIRE** the basic knowledge of maps and drawings and **UNDERSTAND** contours and be able to correlate them on ground.	Cognitive	2	2
2.	**SOLVE** and **ANALYZE** setting of engineering works, geometri design of roads plot longitudina sections and work out quantity earthworks etc.	Cognitive	4	4
3.	**DEMONSTRATE** in small groups handling and use of	Psychom otor	3	9

	survey equipment like total station levels etc for effective monitoring of accuracy and quality of work in the field.			

Course Outlines:

Basic Concepts
Definitions of Surveying and Maps, Types of Maps: Small Scale/ Large Scale Maps, Topographic Map/ Photo Map/ Relief Map, Sign Convention, Index to Map, Map Grid System, Graticules, Geographic Coordinate System, Types of North, Magnetic Declineation, The Concept of Bearing and Directions, Scale: Definition, Methods of expressing scale

Introduction to Survey and Instruments used in Survey
Definitions, Types of survey, Principles of survey, Instruments used for angle measurements i.e. Theodolite, Total Station. Instruments used for distance measurements i.e. chains, steel band, metallic tape, electronic distance measuring equipment, GPS receivers, Measurement of a Baseline and applying corrections.

Traverse with a Total Station
Advantages of traverse over other methods of establishment of survey control points, Measurement of angles and distances with a Total Station, Sources of errors in angle measurements and procedures to nullify errors, Planning the scheme of a closed traverse, computation of bearings of traverse lines from given coordinates and observed angles, adjustment of bearings of a traverse, computation of coordinates, Adjustment of errors in coordinates of a traverse, Plotting the coordinates of traverse stations on a graph/drawing sheet to establish network of control points for drawing map of an area.

Mapping with a Total Station and Computer Software
Traversing with Total Station, recording field data for topographic mapping using total station, Post processing field data and making a topographic map using computer software

Leveling and Contouring
Basic definitions, Introduction to instruments used in leveling i.e. Automatic Level/ Electronic Level, Leveling Staves etc. Setting up and making measurements with an automatic level, observation and booking of field work, reduction of levels, adjustment of misclosures, Definition of Contours, characteristics of contours, uses of contours, methods of contouring.

Books Recommended

1. Surveying principles and Application 9th Edition (2013) by Kavanagh, B, Mastin, T, Pearson.
2. Surveying and Leveling Vol I & II (1998) by T.P Kanetkar, T. P, Kulkarni, S. V, Pune Vidyarthi Griha Prakashan, India

SEMESTER 3

INTRODUCTION TO MICROBIOLOGY **3(3-0)**

Contact Hours	**Credit Hours**
Theory =48	Theory = 3
Practical =0	Practical = 0
Total =48	**Total = 3**

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the bacterial cell	Cognitive	2	1
2	**INTERPRET** the beneficial uses and diseases caused by these microbes	Cognitive	3	3

Course Contents:

1. General introduction and scope: history, basic classifications of microbes)
2. Microbial anatomy
3. Microbial biochemistry
4. Microbial genetics
5. Microbial growth curves and kinetics
6. Microbial isolation, screening, culturing and maintenance
7. Pathogenicity, immunology, immunogenetics, etc.
8. Various microbial diseases
9. Applications of microbes in various fields (environment, industry, food)

Recommended Books:

- Microbiology: An Introduction, by Tortora, Funke, and Case Publisher: 2016, 12th Ed. Benjamin/Cummings Publishing Company.

- Pelczar, J.; Michael, Chan, E. C. S.; Kerg, R. (5th Edition). Microbiology concepts and applications. (Ed. International). McGraw-Hill. International.
- Microbiology, 7th Edition, by Prescott, Harley and Klein, 2007, McGraw-Hill Publishers.
- Atlas. M. Ronald. (1st edition). Principles of Microbiology. 1995, Mosby Year Book, Inc.
- Atlas. M. Ronald. (1st edition). Microorganisms in our world. 1995, Mosby-Year Book, Inc.

ENVIRONMENT AND ANTHROPOLOGY **2 (2+0)**

Theory	= 32	Theory	= 2
Practical	= 0	Practical	= 0
Total	**= 32**	**Total**	**= 2**

Prerequisites
NIL

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the concept of environment	Cognitive	2	3
2.	**UNDERSTAND** the concept of anthropology	Cognitive	2	6
3				7

Objectives:
- To introduce anthropological concepts and research techniques for promoting participation of major groups in environmental management
- To apprise potential engineers about social factors that contribute towards enhancing their professional performance for the good of society and the country
- To enhance understanding about the determinants of human behavior, which ultimately will result in improved individual efficiency

Contents:
- Introduction to cultural anthropology and its relationship with other social sciences
- Participatory approaches to environment and development;

- Participation of major groups: women, youth and others in the management of various types of ecosystems
- Culture and Related Concepts
  - Definition of Culture
  - Types of Culture
  - Elements of Culture
  - Role of Culture in Organization
  - Socialization and Personality
- Population Dynamics
  - World Population Growth and Distribution
  - Population Dynamics in Pakistan
  - Causes and Consequences of Urbanization
  - Population Policy in Pakistan
  - Population and Development
  - Population Forecasting

Recommended Books: (Latest editions where possible)

- Helen K, Eleanor S-O. (2016).” Routledge Handbook of Environmental Anthropology” Routledge **ISBN-**13: 978-1138782877
- Shepherd A., (1998) “Sustainable Rural Development”, St. Martin Press, Inc.,
- Dr. Khan M I, Tahir B A, Amir S, and Akhtar N, (2004). “Toward Participatory Management”, Allama Iqbal Open University.36 Curriculum Division.
- Hafeez, S., Changing Pakistan Society. Karachi, Royal Book Company.
- Maser, C., (1997) Sustainable Community Development: Principles and Concepts. St. Lucie Press,
- Syed, S. H., The State of Migration and Multiculturalism in Pakistan: The Need for Policy and Strategy. Islamabad, UNESCO Report, 2003

SUSTAINABLE URBAN PLANNING **2(2+0)**

Theory	= 32	Theory	= 2
Practical	= 0	Practical	= 0
Total	**= 32**	**Total**	**= 2**

Prerequisites

NIL

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the concept of environment	Cognitive	2	3
2.	**UNDERSTAND** the concept of anthropology	Cognitive	2	6
3				7

Contents:

1. Introduction
- a. Terms and Definitions
- b. Introduction to Sustainable Urban Planning
- c. Scope of Urban Planning

2. The Distribution and Hierarchy of Settlements
- a. Provincial Capitals
- b. Local Capitals
- c. Fully-fledged Towns
- d. Urban Villages or Major Rural Centers
- e. Hamlets
- f. Isolated Farmhouses

3. Sustainability and Compatibility of Land Use
- a. Roads
- b. Town Center (Central Business District)
- c. The Industrial Area
- d. The Residential Neighborhood
- e. Open Spaces and Parks
- f. Neighbourhood Centre and Sub-Centers

4. Farm and Pattern of Urban Spaces
- a. Linear City
- b. Grid Iron Pattern
- c. Ribbon Development and Growth
- d. Radial City

5. Urbanization and Sustainable Development
- a. Spatial Growth Pattern
- b. Urban Sprawl
- c. Slums and squatter settlements

6. Development Plans in Pakistan
- a. Master Plans
- b. Structure Plans
- c. Guided Development Plans
- d. Local Plan
- e. Action Area Plan
- f. Subject Plan

7. Urban Planning and Environment
   a. Urban Planning and Flooding
   b. Impact of Urban Planning on Water Resources
   c. Urban Heat Island

8. Strategies for Improvement of Urban Environment
   a. Urban Agriculture
   b. Shifting of Land Uses

Recommended Books: (Latest editions where possible)

Textbook
City planning for civil engineers, environmental engineers, and surveyors (2009), Kurt W. Bauer

Reference Book
Town Planning in Third World

PROBABILITY AND STATISTICAL ANALYSIS **3 (3+0)**

Objectives:
- To learn the fundamentals of probability
- To introduce basic concepts and techniques of statistical analysis and their application in environmental engineering To introduce statistical packages/software

COURSE LEARNING OUTCOMES:
- Upon successful completion of the course, the student will be able to:

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the concept of environment	Cognitive	2	1
2.	**UNDERSTAND** the concept of anthropology	Cognitive	2	2

Contents:
- Introduction to statistics
- Descriptive Statistics
- Probability and probability distribution
- Random variables
- Sampling statistics
- Hypothesis testing
- Analysis of variance

- Linear regression
- Simulation and other statistical methods
- Statistical packages (e.g. SAS, S-PLUS, SPSS)

Recommended Books: (Latest editions where possible)

- Introduction to probability and statistics for engineers and scientists By Sheldon M. Ross, Elsevier Academic Press, 2009
- Schaum's outline of theory and problems of probability and statistics By Murray R. Spiegel, John J. Schiller, R. Alu Srinivasan, McGraw-Hill; 2nd Edition, 2000.

FLUID MECHANICS **4(3+1)**

Contact Hours		**Credit Hours**	
Theory	= 48	Theory	= 3
Labs	= 48	Labs	= 1
Total	**= 96**	**Total**	**= 4**

Prerequisites

NIL

Course Learning Outcomes:

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

S.No	CLO	Domain	Taxonomy level	PLO
1	**Apply** the fundamental principles of fluid mechanics in environmental systems	Cognitive	3	1
2	**Identify** and **analyze** problems in engineering fluid mechanics	Cognitive	4	2

Contents:

- Introduction to fluid mechanics, hydrostatics, kinematics, hydrodynamics, and hydraulics
- Fluid Statics, pressure intensity and pressure head
- Buoyancy and floatation, equilibrium of floating and submerged bodies.
- Fluid Kinematics, steady and unsteady flow, laminar and turbulent flow, uniform and non-uniform flow
- Hydrodynamics, Bernoulli's equation, Energy equation and its application

- Flow Measurement, Venturimeter, Orifices, Mouthpieces and Nozzles, Pitot tube, Weirs, Notches and Flumes
- Flow in pipes, Darcy-Weisbach equation for flow in pipes, Losses in pipelines, pipes in series and parallel, transmission of energy through pipes, Pipes network
- Uniform flow in open channels, Chezy's and Manning's equations. Bazin's and Kutter's Formula, Most economical rectangular and trapezoidal section

Labs:

1. Demonstration of various parts of Hydraulic Bench
2. Experimental study of laminar and turbulent Flow
3. Experimental study of tube gauges and dead weight pressure gauges
4. Calibration of Orifices
5. Calibration of Venturimeter
6. Calibration of Rectangular and Triangular Notch
7. Verification of Bernoulli's theorem
8. Determination of Metacentric Height
9. Study of various losses through piping arrangements
10. Measurement of velocity and discharge in open channels

Recommended Books: (Latest editions where possible)

- E. Finnemore and Joseph Fanzini, Fluid Mechanics with Engineering Applications, Tenth Edition, 2011, McGraw-Hill Education, ISBN: 1259002276
- Irving Shames, Mechanics of Fluid, Fourth Edition, 2002, McGraw-Hill, ISBN: 0072472103
- R. K. Bansal, Fluid Mechanics and Hydraulic Machines, S.I. Units, Revised Ninth Edition, 2010, Laxmi Publications (P) Ltd, New Delhi, ISBN: 8131808157

ENGINEERING DRAWING & COMPUTER AIDED DESIGN 3(1+2)

Contact Hours:	**Credit Hours:**
Theory =16	Theory = **1.0**
Practical = 96	Practical = **2.0**
Total =112	Total =**3.0**

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**ANALYZE** and **EVALUATE** the problems using imagination while observing different multi-view objects.	Cognitive	6	2
2.	**DEMONSTRATE** individually the drawings of plan, elevation and cross sections of buildings and machine parts	Psychomotor	3	3
3.				5

Course outline:

1. Introduction

a. Introduction to Engineering Graphics
b. S. specification for preparation of drawings
c. Use of drawing instruments and materials.
d. Basic Tools- classification and brief description
e. Lines, Types of lines, configuration of lines and their application, Selection of line thickness
f. Selection of Pencils, Drawing sheets, different sheet sizes and standard layouts.
g. Practicing to draw various types of lines, border lines and title block.

2. Lettering, Numbering and Dimensioning

a. Vertical and inclined single stroke letters
b. Lettering type A and type B, rules for lettering
c. Dimensioning terminology and method of execution. Dimension lines, projection lines, leaders or pointer lines, Arrow heads
d. General rules for dimensioning
e. Methods of dimensioning, Arrangement of dimensions.

3. Geometric Construction

a. Drawing simple geometric objects & introduction to different types of scales.
b. Drawing simple geometric objects (polygon, pentagon and hexagons etc).
c. Introduction to Auto Cad Application of its various tools for Geometric Construction.

4. Orthographic Projection

a. Projection theory, 1st& 3rd angle of Projection
b. Projection of principle views from 3D models
c. Projection of the 3rd principle view from other two principle views
d. Application of various tools of Auto Cad for drawing orthographic views in 1st and 3rd angle of projection, of 3-D objects.

5. Sectional views and Auxiliary views

a. Types of section views & Sectioning techniques

6. Building Drawing

a. Basic terminologies regarding building materials, Understanding of basic stages and elements of Architectural drawing, introduction & characteristics of diff. types of drawings developed for any Civil Engg project., Design of boundary wall
b. Building Architecture and Planning, Definitions Importance and Applications of Section, Elevation and plan of building, Architectural design of a building. 2-D views development based on simple assembly drawings, machine parts and building components
c. Application of various tools of Auto Cad for Building Drawing

Text and reference books:

1. A Textbook of Engineering Drawing: Along with an Introduction to AutoCAD (2015) by Roop Lal, Ramakant Rana
2. Engineering Drawing and Graphics Using Autocad, 3/e by T Jeyapoovan
3. Basics of Engineering Drawing by Z. A. Siddiqui, Dr M. Ashraf and S. A. Siddiqui.
4. Engineering Drawing with an introduction to AutoCAD by D. A. Jolhe
5. Civil Engineering Drawing by Gurcharan Singh.

ENGINEERING ECONOMICS (2+0)

Course Learning Outcomes (CLOs):

After studying this course, the learners will be able to:- .

S. No	Course Learning Outcomes	Domain	Taxonomy level	Program Learning Outcome
1	**Describe** fundamental concepts of economics and Apply appropriate	Cognitive	3	7

	economic theories in the field of engineering			
2	**Illustrate** engineering project according to economic perspective.	Cognitive	2	11

Course outlines:

- Introduction to economics and its importance in engineering field.
- Basic principles of engineering economics
- Engineering costs & estimates
- Externalities and market failure
- Marginal willingness to pay
- Cost benefit analysis, discounting and present value of net benefit.
- Rate of return and incremental analysis
- Environmental pollutants according to economic criteria
- Economic benefits of renewable and non-renewable resources.
- Pollution control, targets and economic instruments.
- Economics of trans-boundary pollution problems

Recommended Books: (Latest editions where possible)

- William G. Sullivan, Elin M. Wicks and C. Patrick Koelling, 2015, Engieering Economy, 16th edition, ISBN: 978-0133439274.
- Hanley, N. J., F Shogren and B White, 2002, Environmental Economics in theory and practice, Palgrave Macmillan
- David W. Pearce Environmental Economics: An Elementary Introduction
- Perman, R, Ma, Y, McGilvray, J. 1996. Environmental and Natural Resource Economics. Longman, London and New York.
- Chan S. Park, Contemporary Engineering Economics, 5th ed., Pearson Prentice Hall, 2016,
- James R. K. 1998. The Economic Approach to Environmental and Natural Resources. Harcourt Brace College Publishers.
- Tietenberg, T, Environmental and Natural Resource Economics. 2nd Edition, 1998, Harper Collins Publishers.

SEMESTER 4

WATER SUPPLY AND WASTEWATER COLLECTIONS 3(2-1)

Contact Hours
Theory = 32

Credit Hours
Theory = 2

Labs	= 48	Practical	= 1
Total	**= 80**	**Total**	**=3**

Prerequisites
NIL
Course Learning Outcomes:

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

S.No	CLO	Domain	Taxonomy level	PLO
1	**IDENTIFY** the concepts and **DESCRIBE** the process for the design of water supply schemes	Cognitive	2	1
2	**ANALYSIS** and **DESIGN** of water supply and wastewater collection systems	Cognitive	5	2
3	**DEMONSTRATE** design of water distribution network using modern softwares	Psychomotor	3	5

Course Contents:

Part I: Water Supply Network

- Introduction to water supply schemes: Brief history of water supply system, Basic terms and definitions, Components of water supply schemes, Types of water supply schemes, Rural and urban water supply schemes
- Water Demand and Supply: Population forecast (linear method, geometric growth method and curve fitting method etc.), Water uses and consumption, Types and variation in water demands (peak flow, maximum flow, average flow etc.), Factor affecting water demand
- Preliminary Investigations: Concept of design periods of water supply components, Factor affecting design period of water supply component design, Criteria of water source (ground water or surface water) selection, Source investigation including electric resistivity surveys, electric well logging etc., Installation of test tube wells to ascertain safe yield of the aquifer, Safe inter tube well distance

- Hydraulics of Water Supply Schemes: Layout of water supply schemes, Hydraulic design of water transmission lines from source to point distribution, Description of Hardy Cross method and its application, Discussion on complete design criteria
- Pipes, Joints & Valves: Type of piping materials, joints and valves (air relief values, altitude valve, sluice valves etc.), Characteristics of piping materials, Design life of pipe
- C values of pipes, joint types and their life
- Tube Well and Overhead Reservoir (OHR): Introduction, Design parameters of tube well, Detailed design of tube well, Capacity of OHR, Location of OHR, Concept of balancing reservoir
- Concept of water hammer in the big transmission lines and methods to avoid water hammer

Part II: Wastewater Collections

- Introduction to Sewerage System: Basic terms and definitions, Basic definitions and terms, Components of wastewater collection system, Types of wastewater collection systems, Urban and rural wastewater collection systems
- Wastewater Generation: Estimation of wastewater (average flows, peak flows), Wastewater characteristics
- Design of sanitary and storm sewers: Concept of self-cleansing velocity, Hydraulic design of sewer, Development of complete hydraulic statement for the sewer network for sanitary and storm sewer, Sewer profiles, Concepts and calculations of Invert levels, Jointing of sewer, Inflow and infiltration problems into the waste water systems, Steps involved in the construction of sewers, Sewer bedding and its types, Various appurtenances in sewer system (manholes, drop manholes etc.)
- Pipes, Joints & Valves: Type of piping materials, joints and valves, Characteristics of piping materials, Design life of pipes
- Disposal Station: Components of sewage disposal station (wet well, dry well, screens), Design criteria for sewage disposal station, Types of pumps and its characteristics, Concept and design of septic tank and soakage pits for individual houses
- Health risks/problems associated with faulty design and configurations of Water Supply and Sewage Network

Labs:

- EPA NET (Software): Introduction of EPA NET, Definition of basic components, Detailed design of water distribution network using EPA NET

Recommended Books: (Latest editions where possible)

- Nazih K. Shammas, Lawrence K. Wang, Water Supply and Wastewater Removal, 3rd Edition, 2010, Wiley, ISBN: 978-0470411926
- Mark. J. Hammer, Water and Waste Water Technology, Seven Edition 2011 Prentice Hall, ISBN: 0135114047
- Terence J. McGhee and E. W. Steel, Water Supply and Sewerage, Sixth Edition, 1991, McGraw-Hill, ISBN: 0070609381
- Paul Bizier, Gravity Sanitary Sewer Design and Construction, 2007, 2nd Edition (ASCE)

ENVIRONMENTAL MICROBIOLOGY **3(2-1)**

Contact Hours	**Credit Hours**
Theory = 32	Theory =2
Practical =16	Practical =1
Total =48	**Total =3**

Pre-Requisite:
Introduction to Microbiology

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	Apply the basic principles of microbial metabolism for environmental remediation.	Cognitive	2	4

Contents:

1. Brief overview of microbiology (basic classification, microbial growth)
2. Relationship of microbiology with environmental engineering.
3. Biosafety rules and regulations during isolation and processing of microbes
4. Microbes-microbes interaction
5. Microbes-environment interaction
6. Microbial role in biogeochemical cycles
7. Microbial pathogens in the environment
8. Rhizobacteria, endophytic and symbiotic bacteria
9. Role of microbes in reclamation of the polluted environment
10. Role of microbes in aerobic and anaerobic biological waste treatment.

Lab work:

1. Microscopy
2. Microbial isolation from soil and water
3. Microbial identification using various chemical and microscopic methods
4. Microbial dilution and plating methods
5. Coliform MPN Test
6. Bioremediation

Recommended Books:

1. Ian PepperCharles GerbaTerry Gentry, 2014. Environmental Microbiology. Elsevier Publishers, Netherlands.
2. Ralph Mitches and Ji-Dong Gu., 2010 Environmental Microbiology, McGraw-Hill Inc.
3. Prescott L. M., Harley G. P., Klei C. A. 1992. Microbiology (4th edition), McGraw-Hill Inc.
4. Telezar M. A., Chan E. C. S. Microbiology: Concepts and Applications, McGraw-Hill Inc.
5. Denyer S. P., Gorman S. P. Microbial Bioskills: Formation and Control, McGraw-Hill Inc.
6. Mitches, R., Environmental Microbiology. McGraw-Hill Inc.
7. Denyer, S.P., Gorman, S.P. Microbial Bioskills: Formation and Control, 1st edition, 1993, McGraw-Hill Inc.

ECOLOGICAL MANAGEMENT **2 (2+0)**

Theory	= 32	Theory	= 2
Practical	= 0	Practical	= 0
Total	**= 32**	**Total**	**= 2**

Prerequisites

NIL

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the Importance of Ecological Management	Cognitive	2	6
3.	**APPLY** the concepts of Ecology in environmental engineering	Psychomotor	3	7

Objectives:

- To provide basic concepts of ecosystems
- To learn management techniques for sustainable development of ecosystem and environment

Contents:

- Basic concepts in ecology
- Structure of ecosystem
- Energy and material flow within ecosystem. Succession: (only basic concepts). Ecosystem productivity , food webs and food chains
- Types of ecosystems and their management
- Biodiversity and ecological sustainability
- Nutrient cycles and Eutrophication
- Populations / communities and their dynamics and interaction.
- Species, and extinction,
- Impact of unsustainable development activities on man and ecosystem.

Recommended Books:

- Project Management Institute Project Management Institute 2017. A Guide to the Project Management Body of Knowledge, Third Edition (PMBOK Guides) - 589 pages
- Garton C, and McCulloch, E., 2012. Fundamentals of Technology Project Management. MC Press, LLC, 2012 - Computers - 705 pages
- Scott Berkun, 2005, The Art of Project Management. O'Reilly, 488 pages

NUMERICAL ANALYSIS **3 (3+0)**

Objective:

- To introduce and acquaint the various techniques for solving linear and non-linear equations using various numerical methods

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the concept of environment	Cognitive	2	2

Contents:

- Solution of Non-Linear Equations: Simple interaction, Bisection method, Newton's method, Secant method, Method of false position.
- Finite Differences: Difference operations and tables, differences of polynomials, Newton's and Gauss interpolating technique for equally spaced data, simple theorems on divided differences, Newton's formulation for unequal intervals, Lagrange's formulation of interpolation, numerical differentiation, curve fitting by the method of least squares.
- Numerical Integration: Review of integration concept and their physical significance for engineering, Trapezoidal and *Simson's* rule numerical integration techniques.
- Solution of Linear Simultaneous Equations: Jacobi's method, Gauss-Settle method, Sparse matrices, solution of differential equations, Euler and modified Euler methods, Runge Kutta and Kutta Merson methods.
- Eigen-values and Eigen-vectors: Interactive and transformation methods, Eigen-values of tri-diagonal matrix.
- Solution of Polynomial Equations: Polynomial equations, finding initial approximations and complete solution of polynomial regression analysis.

Recommended Books: (Latest editions where possible)

- Murray R. S., Schaum's Outline of Complex Variables, 2nd Edition, 2009
- Scheid F. J., Schaum's outline of theory and problems of numerical analysis, 2nd Edition, McGraw Hill, 1989
- Fundamentals of Engineering Numerical Analysis by ParvizMoin, Cambridge University Press, 2010

HYDROLOGY **3(2-1)**

Contact Hours	**Credit Hours**
Theory = 32	Theory = 2
Labs = 48	Labs = 1
Total = 80	**Total = 3**

Prerequisites

NIL

Course Learning Outcomes:

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

S.No	CLO	Domain	Taxonomy level	PLO
1	**Apply** the knowledge of hydrological cycle and hydrological principles for estimating water balance	Cognitive	3	1
2	**Analyze** various hydrological components using appropriate hydrological techniques (surface and groundwater)	Cognitive	4	2

Contents:

- Definitions: Hydrology, hydrological cycle, importance and applications of hydrology.
- Atmosphere and its composition, solar radiation as a source of heat, air temperature. Relative humidity, dew point. Saturation deficit. Measuring devices for the above mentioned parameters. Global climate change.
- Precipitation: Types of precipitation, factors required for precipitation, measurement of precipitation, interpretation of precipitation data, computation of average rainfall over a basin. Effects of precipitation on the hydrological regime of a region.
- Evaporation and Transpiration: Factors affecting evaporation, measurement of evaporation, evapo-transpiration. Humidity-evaporation / transpiration relationship.
- Stream Flow: Water stage and its measurement, selection of site for stage recorder, selection of control and metering section, methods of measurement of stream flow, interpretation of stream flow data. Instrumentation (analogue & digital), monitoring of flow.
- Runoff and Hydrographs: Rainfall-Runoff relationship, Factors affecting runoff, estimating the volume of storm runoff. Characteristic of Hydrograph, components of a hydrograph, hydrograph separation, estimating the volume of direct runoff, introduction to unit hydrograph concept, S-curve, Application of probability in determining maxima/minima of discharge. Types of histogram and distribution, time of concentration.
- Stream Flow Routing Introduction to floods and its causes, frequency and duration analysis. Reservoir routing, channel routing. Flood Control – methods & management.
- Sub-surface / Groundwater: Introduction, sources and discharge of ground water. Water table and confined and unconfined aquifers,

groundwater hydraulics, pumping test. Drawdown, yield. Methods for determining subsurface water storage.

Labs:

1. Measurement of relative humidity using Pshychrometer
2. Measurement of rainfall using different rain gages
3. Estimation of average rainfall by using Isohyetal and Theissen Polygon methods
4. Measurement of evaporation using different types of evaporation pans
5. Study working of weather station
6. Measurement of water table depth
7. Determination of ground water flow rates and direction
8. Determination of well losses and well efficiency
9. Determination of hydraulic conductivity by laboratory methods
10. Determination of hydraulic conductivity by field methods
11. Determination of aquifer properties
12. Field visits

Recommended Book:

- S.E. Serrano, Hydrology for Engineers, Geologists & Environmental Professionals, 2nd Edition, 2010, HydroScience, Incorporated;, ISBN: 0965564347.
- Warren Viessman, Jr. and Gary L. Lewis, Introduction to Hydrology, Fifth Edition, 2002, Prentice Hall, ISBN: 067399337X
- Victor Miguel Ponce, Engineering Hydrology: Principles and Practices, First Edition, 1994, Prentice Hall, ISBN: 0133154661

Teaching Methods:

- Lectures
- Demonstration and Hands-on
- Assignments
- Quizzes
- Field Visits

THERMODYNAMICS **3(2+1)**

Contact Hours		**Credit Hours**	
Theory	= 32	Theory	= 2
Practical	= 0	Practical	= 1
Total	**= 32**	**Total**	**= 3**

Prerequisites

Introduction to Environmental Engineering

Course Learning Outcomes (CLOs):
After studying this course, the learners will be able to:-

S.No	Course Learning Outcomes	Domain	Taxonomy level	Program Learning Outcome
1	**Acquainted** with basic principles of Thermodynamics to develop an intuitive understanding	Cognitive	1	1
2	**Use** of thermodynamics applications in professional practice	Cognitive	3	2

Course outlines:

- Thermodynamic systems, properties, state, processes, ideal gas equation of state, work and heat.
- The first law of thermodynamics, cyclic processes and non-cyclic processes applied to closed and open systems, stored energy, internal energy, flow energy, enthalpy, specific heats, and statements of the second law of thermodynamics.
- Processes in formation of steam, property diagrams; property tables, Rankine cycle.
- Classification & working of different types of steam generators, mountings and accessories, performance of steam generators.
- Classification of steam turbines, overall efficiency of steam turbines.
- Gas turbine cycles, applications, combustion process.
- Classification of air compressors, working of reciprocating and rotary air compressors, performance of compressors.
- Classification and working mechanism of internal combustion engines.

Practical/Lab. Work:

- Practical related to the topic covered in theoretical section.

Recommended Books:

- Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner, Margaret Bailey, “Fundamentals of Engineering Thermodynamics”, John Wiley & Sons, 7th Edition, 2010.
- Sanford Klein, Gregory Nellis,” Thermodynamics”, Cambridge University Press, 1st Edition, 2008.

- T. D. Eastop and Ma Conkey, Applied Thermodynamics for Engineering. 5th Edition, 1993, Pearson Publishers, UK
- Rayner Joel, Technologist Basic Engineering Thermodynamics G. F. C. Rogers and Y. R. Mayhew Engineering Thermodynamics, Work and Heat Transfer.
- Yunus A. Cengel, Michael A. Boles," Thermodynamics: An Engineering Approach", 7th Edition, 2001, McGraw-Hill, USA.

SEMESTER 5

WATER TREATMENT **3(2-1)**

Contact Hours Credit Hours

Theory = 32	Theory =2
Practical = 48	Practical =1
Total = 80	**Total =3**

Prerequisites
Introduction to Environmental Engineering

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**DENTIFY** fundamentals of water treatment	Cognitive	2	1
2.	**ANALYZE** water treatment unit operations and processes and EVALUATE water treatment unit design	Cognitive	5	3
3.	Measure and **INTERPRET** water quality parameters and Estimate coagulant, flocculent, and chlorine dosages	Psychomotor	3	9

Course Outline

1. **Water Quantities and Water Quality**
   a. Water demand
   b. Water quality
2. **Preliminary Unit Operations and Processes**

a. Pre-treatment unit operations

3. Coagulation and Flocculation

a. Coagulation
b. Flocculation

4. Sedimentation

a. Settling Types
b. Sedimentation Basins
c. Inclined Settling Devices

5. Filtration

a. Single-Medium Filters
b. Multimedia Filters
c. Upflow Filtration

6. Adsorption

a. Column Contacting Techniques and Equipment
b. Fixed-Bed Adsorption Columns
c. Moving-Bed Countercurrent Adsorption Columns
d. Fluidized Beds

7. Ion Exchange

a. Softening and Demineralization
b. Ammonia Removal

8. Disinfection

a. Chlorination
b. Ozonation
c. UV Irradiation

Labs

a. Preparation of solution and their standardization
b. Measurement of temperature, pH and conductivity of water samples
c. Determination of water turbidity using the Standard Method
d. Determination of water alkalinity
e. Determination of water hardness

Text Books (s)

- *"*MWH's Water Treatment: Principles and Design" by John C. Crittenden, R. Rhodes Trussell, David W. Hand, Kerry J. Howe, George Tchobanoglous (Third Edition, 2012)
- "Unit Operations and Processes in Environmental Engineering*"* by Tom D. Reynolds and Paul A. Richards (Second Edition, 1996)
- Mark M. Benjamin, Desmond F. Lawler *"*Water Quality Engineering: Physical / Chemical Treatment Processes*"* 1st Edition

PROFESSIONAL ETHICS **2(2-0)**

Contact Hours	**Credit Hours**
Theory = 32	Theory = 2
Practical= 0	Practical = 0

Total = 32 **Total = 2**

Prerequisites

NIL

Course Learning Outcomes:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Identify** and **describe** relevant theoretical concepts related to professional ethics	Cognitive	2	6
2.	**Recognize** and **apply** ethical principles in various academic, professional, social, or personal contexts.	Cognitive	3	8

COURSE OUTLINE:

1. **Introduction:**
   Social Living: Society & its nature, the social structure, culture and the value system. Important theories. Islamic approach to ethics.

2. **Engineering Ethics:**
   Senses of Engineering Ethics – Variety of moral issues – Types of inquiry – Moral dilemmas. Moral Autonomy – Kohlberg's theory – Gilligan's theory – Consensus and Controversy – Professions and Professionalism – Professional ideals and virtues – Theories about right action – Self-interest – Customs and religion – Use of Ethical Theories

3. **Engineering as Social:**
   Engineering as experimentation – Engineers as responsible experimenters – Codes of Ethics – A Balanced Outlook on Law – The Challenger Case Study.

4. **Engineer's Responsibility for Safety:**
   Safety and risk – Assessment of safety and risk – Risk Benefit Analysis – Reducing risk – The Three Mile Island and Chernobyl Case Studies

5. Responsibilities and Rights:
Collegiality and loyalty – Respect for Authority – Collective Bargaining – Confidentiality – Conflicts of Interest – Occupational Crime – Professional Rights – Employee Rights – Discrimination.

6. Global Issues:
Multinational Corporations – Environmental Ethics – Computer Ethics – Weapons Development – Engineers as Managers – Consulting Engineers – Engineers as Expert Witnesses and Advisors – Moral Leadership – Sample code of conduct.

Code of Conduct of Pakistan Engineering Council,
Code of Conduct and Ethics of National Accountability Bureau (NAB) Islamabad

Recommended Books:

- Morton Winston & Ralph Edelbach (2013), Society, Ethics and Technology, Fifth Edition, Wadsworth Publishing; ISBN: 1133943551
- Mike Martin and Roland Schinzinger (2009), Introduction to Engineering Ethics (Basic Engineering Series and Tools), Second Edition, McGraw-Hill Education, New York, ISBN: 0072483113
- Charles B. Fledderman (2012), Engineering Ethics, Fourth Edition, Pearson Prentice Hall, Upper Saddle River, ISBN: 0132145219
- Stephen L. Carter (1996), Integrity, Basic Books, Harper Perennial; English Language Edition, ISBN: 0060928077
- Tom Rusk (1993), The Power of Ethical Persuasion: From Conflict to Partnership at Work and in Private Life, Viking Press, New York, ISBN: 0670846171
- Code of Conduct (SRO 1463 (1) / 78), Pakistan Engineering Council, Islamabad
- Code of Conduct and Ethics, National Accountability Bureau, Islamabad

SOIL MECHANICS **4(3-1)**

Contact Hours	**Credit Hours**
Theory = 48	Theory = 3
Labs = 48	Labs = 1
Total = 96	**Total = 4**

Prerequisites

NIL

Course Learning Outcomes:

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

S.No	CLO	Domain	Taxonomy level	PLO
1	**Identify** relationships between physical characteristics and mechanical properties of soil	Cognitive	1	1
2	**Develop** a comprehensive soil investigation report	Cognitive	4	9

Contents:

- Significance. Soil, rock and their types and formation. Physical properties of soil: water content, voids ratio, porosity, degree of saturation, specific gravity, unit weight and their determination
- Mass-volume relationships (density; in-situ, bulk, field)
- Importance of classification tests. Atterberg's limits, grain size distribution (coarse & fine soils), classification systems (ASTM, AASHTO, Unified, etc.)
- Soil exploration, purpose and methods of soil exploration.
- Probing, test trenches and pits, auger boring, wash boring, rotary drilling, and geophysical methods, soil samplers.
- Disturbed and undisturbed samples. Introduction to geotechnical report writing, Bore log.
- Darcy's law, factors affecting permeability, laboratory and field determination of permeability, hydraulic conductivity, Surface tension, capillary and its effects, suction in soils.
- Seepage force. Introduction to flow net. Estimation of seepage quantity.
- Quick sand condition. Sand boiling, Filters (Slow and Rapid sand filters).
- Fundamental concepts and definitions moisture-density relationship (OMC Curve), compaction standards (Proctor Test), factors affecting compaction, field moisture control and measurements of in-situ density.
- Field compaction equipment (rolling, tamping, vibratory).
- Mechanics of consolidation, theory of one dimensional consolidation, assumptions and validity, types of foundation

- Compression index, co-efficient of compressibility, time factor,
- Coefficient of volume change and degree of consolidation,
- Primary and secondary consolidation. Normal and pre-consolidated soils. Creep, Differential Settlement.

Labs:

1. Determination of Moisture Content/water content in soil by oven drying method
2. Determination of specific gravity of fine soil by pycnometer/relative density bottle
3. Determination of field density of soil by Sand Cone Apparatus
4. Determination of optimum moisture content and maximum density by Standard Compaction Test
5. Characterization of coarse grained soil by sieve analysis and developing particle size distribution curve
6. Characterization of fine grained soil by Hydrometer Analysis and developing PSD curve
7. Determine fineness of soil
8. Determine liquid limit of soils
9. Determining plastic limit of soils
10. Determine shrinkage limit of soils
11. Determine hydraulic conductivity of fine grained soil by variable head method
12. Determine hydraulic conductivity of coarse grained soil by constant head method

Recommended Books:

- R. Whitlow, Basic Soil Mechanics, Fourth Edition, 2000, Prentice Hall, ISBN: 0582381096
- Karl Terzaghi, Theoretical Soil Mechanics, Seventh Printing, 1954, John Wiley and Sons, ASIN: B000IN4IUW
- T. William Lambe and Robert V. Whitman, Soil Mechanics, International Edition, 1979, Wiley & Sons, ISBN: 0471024910

SOLID WASTE ENGINEERING & MANAGEMENT **4(3-1)**

Contact Hours	**Credit Hours**
Theory = 48	Theory = 3
Labs = 48	Labs = 1
Total = 96	**Total = 4**

Prerequisites

NIL

Course Learning Outcomes (CLOs):

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

S.No	Course Learning Outcomes	Domain	Taxonomy level	Program Learning Outcome
1	**Understand** the sources, composition and characteristics of the solid waste	Cognitive	1	3
2	**Distinguish** the waste generation & collection requirement and **Analyze** optimum collection system	Cognitive	4	4
3	**Design** the final disposal/management of solid waste	Cognitive	5	6

Course outlines:

- Sources of solid waste i.e. Municipal, Industrial, Nuclear, and others.
- Solid waste generation.
- Characteristics of solid waste management.
- Waste quantification, waste minimization and waste processes.
- Waste collection, transfer, scavenging, transport and disposal.
- Recycling issues, aluminum, paper and cardboard, plastics, yard waste, organic wastes, construction and demolition wastes and others.
- Composting and its types, anaerobic digestion and its types, Incineration, Gasification & Pyrolysis.
- Landfills types, siting and design considerations, control of landfill leachate & gases
- Thermal treatment.
- Disposal of Integrated Waste, Underground Storage Tanks Construction, Installation & Closure.

Practical/Lab. Work:

- Practical related to the topic covered in theoretical section.

Recommended Books:

- Solid Waste Engineering: A Global Perspective 3rd Edition (2016) by William A. Worrell, P. AarneVesilind, Christian Ludwig
- Integrated Solid Waste Management, by John Tchanobaglus, McGraw Hill
- Shah, Kanti L. Basic of Solid & Hazardous Waste Management Technology, Prentice Hall.
- Tchobanoglous, G., Theisen, H. and Vigil, S. (1993). Integrated Solid Waste Management: Engineering Principles and Management Issues
- Tchobanoglous, George and Kreith, Frank (2002). Handbook of Solid Waste Management, Second Edition

GEOGRAPHICAL INFORMATION SYSTEM 3(2-1)

Contact Hours Credit Hours

Theory = 32	Theory = 2
Practical = 48	Practical = 1
Total = 80	**Total = 3**

Prerequisites
NIL

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**IDENTIFY** fundamentals of geographical information system (science)	Cognitive	2	4
2.	**ANALYZE** geospatial data	Cognitive	4	2
3.	**APPLY** GIS concepts and tools for solving problems	Psychomotor	3	5

Course Outline

1. Introduction and Overview of GIS
2. Data Types and Data Models/structures

a. Raster Data Models, Vector Data Models
b. Conversion Between Raster and Vector Data Models
c. ArcGIS supported data formats
d. File Geodatabase and tables

3. Earth Model
   a. Representing the Earth
   b. Map Projections
   c. Geographic and projected coordinate systems,
4. Visualization of Spatial data and Basics of Cartography
5. Spatial Data Queries and Analysis
6. GIS Modeling and Modeling Tools
7. Introduction to Global Positioning System (GPS)
8. Spatial Analysis
9. Network analysis
10. 3D analysis
11. GIS Applications in multidisciplinary fields utilizing GIS concepts and tools

Lab Outline:

Main focus on providing hands-on experience using latest GIS software (ArcGIS 10x or latest, ILWIS, QGIS) in understanding and applying GIS concepts introduced in this course including

1. Viewing
2. Projecting
3. Digitizing (editing and creating GIS data)
4. Spatial and non-spatial Queries
5. Processing tabular data
6. Geo-processing
7. Geo-referencing
8. Spatial Analysis
9. Modeling
10. Presenting maps (labeling, layouts)
11. ESRI online courses

Text Books (s)

- Bolstad, P. (2012), “GIS Fundamentals”, 4th Ed, Atlas Books.
- Chang, K. T. (2015), “Introduction to Geographical Information Systems” Higher Education, McGraw-Hill. ISBN: 1259613445, 9781259613449
- Clarke, K. (2010), “Getting started with Geographic Information System”, 5th Edition, Prentice Hall, New York. ISBN –10: 0131494988
- Heywood, I., Cornelius, S. and Carver, S. (2006), “An introduction to Geographic Information System”, 3rd Edition, Prentice Hall. ISBN-10: 0131293176

- Huisman, O. and de By, R. A.(2009), “Principles of Geographic Information Systems: An Introductory Textbook”, ITC Educational Textbook Series; 1, ISBN 978-90-6164-269-5
- Longley, P. A., Goodchild, M. F., Maguire, D. J., and David, W. R. (2015), “Geographic Information Systems and Sciences”, 4th EDd. John Wiley & Sons.
- Kennedy, Michael. The global positioning system and ArcGIS. 3rd Ed. CRC Press, 2009.
- Shahab Fazal ”GIS BASIC”. (2008). Copyright © 2008, New Age International (P) Ltd., Publishers.
- SGorr, Wilpen L., and Kristen S. Kurland. "1Basic Workbook." (2014). **[For Lab]**

SEMESTER 6

PROJECT PLANNING AND MANAGEMENT **3(3+0)**

Contact Hours	**Credit Hours**
Theory = 32	Theory = 3
Practical = 0	Practical = 0
Total = 32	**Total = 3**

Prerequisites
NIL

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the importance of planning and management of projects	Cognitive	2	4
2.	**EVALUATE** key phases of a project w.r.t. time and budget	Cognitive	5	11
3.	**APPLY** EIA concepts in environmental engineering	Psychomotor	3	3

Course Outline
1. Introduction to project planning and management and understanding of its need

2. Defining project life cycle (process of initiating, planning/scheduling/cost, executing, controlling and closing the project)
3. Project approval processes
4. Introduction to contracting and tendering
5. Developing project team, defining role of team players, developing leadership skills,
6. Responsibility, accountability, and effective communication skills, and managing conflicts.
7. Managing the project scope, time, work flow (Gantt Charts, Network diagram, Pert Charts, CPM, etc.), project resources, project quality, project human resource requirements,
8. Managing project communication (reports, meetings, correspondence, etc.), management of risk and changes in the project.
9. Project monitoring guidelines, setting up monitoring and control process.

Text Books (s)

- A Guide to the Project Management Body of Knowledge (PMBOK® Guide)—Fifth Edition (ENGLISH) (New edition will be released in 2017)
- Project Management: A Systems Approach to Planning, Scheduling, and Controlling by Harold, PhD. Kerzner, 11 Ed. 2013
- Saarniniemi, Jose. "Risk management in ERP Projects: Case: Upgrading to Microsoft Dynamics NAV 2009." (2013).
- The Art of Project Management (Theory in Practice (O'Reilly)) by Scott Berkun

WASTEWATER ENGINEERING **3(2-1)**

Contact Hours	**Credit Hours**
Theory =32	Theory = 2
Practical =48	Practical = 1
Total =80	**Total = 3**

Prerequisites

Introduction to Environmental Engineering

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** fundamentals of wastewater generation	Cognitive	2	3
2.	**ANALYZE** waste water treatment unit operations and processes and **EVALUATE** water treatment unit design.	Cognitive	5	4
3.	**DEMONSTRATE** measuremen physico-chemical and biologica wastewater quality parameters	Psychom otor	3	9

Course Outline

1. Wastewater generation and impurities
   Strengths and characteristics of wastewater, design criteria, types of treatment units, sizing of units, reactions and reactors
2. Septic Tank
   a. Principles of septic tank
   b. Leachfield
   c. Design of septic tank
3. Waste Stabilization Pond (WSP)
   a. Principles of WSP
   b. Types of WSP
   c. Arrangement of WSP
   d. Design of WSP
4. Preliminary and Primary Treatment Units
   - Approach channel, equalization basins, screen chamber, grit chambers, aerated grit chambers, skimming tank
   - Primary settling tank, functions, design criteria, flotation systems, design considerations
5. Aerobic Biological Treatment of Wastewater
   - Concept of biological treatment
   - Classification of treatment processes
   - Aerobic biological treatment
   - bio-kinetic coefficients
   - Design considerations
6. Aerobic Suspended Growth Treatment
   a. Principles of aerobic suspended growth systems
   b. Types of suspended growth systems
   c. Conventional activated sludge system
   d. Extended aeration system
   e. Aerated lagoon system
7. Aerobic Attached Growth Treatment
   a. Principles of aerobic attached growth systems

b. Types of attached growth systems
c. Trickling filter system
d. Rotatory Biological Contact Reactors

8. Anaerobic Biological Wastewater Treatment
   - Removal concept and system concept, anaerobic reactors
9. Sludge Management
   a. Sludge management techniques
   b. Design of drying beds
10. Constructed Wetlands
   a. Introduction of construction wetlands
   b. Types of construction wetland
   c. Design of construction wetlands

Labs

a. Measurement of Dissolved Oxygen by Wrinkler Method
b. Estimation of Total and Faecal Coliforms using
c. Determination of Chemical Oxygen demand of wastewater
d. Determination of Biochemical Oxygen Demand of wastewater
e. Determination of Residual Chlorine by Iodometric Method
f. Determination of Solids (TS, TDS, TSS, SS, TVF and TVS) in Water /Wastewater Samples
g. Estimation of the Optimum Coagulant Dose by Jar Test Apparatus
h. Determination of Nitrate-Nitrogen by Spectroscopy

Recommended Book

- Wastewater Treatment: Concepts and Design Approach (2nd Edition, 2013) by G.L Karia and R.A. Christian
- -*"Wastewater Engineering, Treatment and Resource Recovery"*, 5th Edition by Metcalf & Eddy (2013)
- -*"Biological Wastewater Treatment"*, Third Edition 3rd Edition by C. P. Leslie Grady Jr (2011)
- -*"Theory and Practice of Water and Wastewater Treatment"*, Ronald L. Droste (1996)

ENVIRONMENTAL IMPACT ASSESSMENT **3(3-0)**

Contact Hours		**Credit Hours**	
Theory	= 32	Theory	=3
Practical	= 0	Practical	=0
Total	**= 32**	**Total**	**=3**

Prerequisites

NIL

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

S.No	CLO	Domain	Taxonomy level	PLO
1	**Analyze** and mitigate significant impacts of any project on environment and society	Cognitive	4	2
2	**Apply** EIA concepts on real-life problems	Psychomotor	3	6

Course Outline

- **EIA Basics**
- Principles, Introduction, Definition, Basic Concepts, types of assessment, Environment Impact Statement (EIS)
- **Decision-making theory and practice:** EIA as a decisions-making instrument
- **Environmental issues of Pakistan:**
- **Implementation of EIA:** Role of EPAs, EPDs etc.
- **EIA Process:** Screening, Scoping, Checklist for rapid environmental assessment (REA) of ADB, Baseline Data, Identification of Impacts and Evaluation of Alternatives, Assessing the Impacts (methods and techniques), Assessing the Impacts (methods and techniques), Mitigation (importance, approaches and methods) and identification of suitable alternatives, minimization of pollution and remedial measures, Reporting (Pakistan guidelines for reporting EIA, required legal documents and guidelines), EIA quality review, EIA Follow-up (objective, component, regulations, process and challenges), Public Participation and Consultation, EIA Reports, Environmental Management Plans (EMPs), Monitoring, Auditing
- **EIA Effectiveness:** Framework, Criteria, Introduction to Strategic Environmental Assessment (SEA)

Text Books (s)

- Environmental Impact Assessment Course Curriculum for Higher Education Institutions in Pakistan by Fischer, T. B. and Nadeem, O (2014), IUCN, Pakistan, http://cmsdata.iucn.org/downloads/niap___eia_curriculum_for_hei.pdf.

- Introduction to Environmental Impact Assessment, Fourth Edition (2012). John Glasson, Riki Therivel, Andrew Chadwick. Publisher: Routledge (Third Edition Available at http://site.iugaza.edu.ps/sghabayen/files/2013/02/John_Glasson_Riki_Therivel_Andrew_Chadwick_IntBookos.org_.pdf
- Environmental Impact Assessment (EIA) Handbook for Pakistan (2014). Author: Thomas B. Fischer. Publisher: IUCN, Pakistan. http://cmsdata.iucn.org/downloads/niap___eia_handbook.pdf
- Environmental Impact Assessment by Larry W Cantt (2nd Chapter of Environmental Engineers' Handbook by David H.F. Liu, Bela G. Liptak 1999 CRC Press LLC)
- Environmental Impact Assessment: A Guide to Best Professional Practices by Charles H. Eccleston, CRC Press, Taylor and Francis Group, LLC, 2011
- Methods of Environmental Impact Assessment, Third Edition (2009). Peter Morris and Riki Therivel. Publisher: Routledge

AIR AND NOISE POLLUTION CONTROL **4(3-1)**

Contact Hours		**Credit Hours**	
Theory	=48	Theory	=3
Practical	=48	Practical	=1
Total	**=96**	**Total**	**=4**

Prerequisites
NIL

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

S.No	CLO	Domain	Taxonomy level	PLO
1	**ANALYZE** their impacts on environment and society	Cognitive	4	2
2.	**PRACTICE** air and noise pollution instrumentation and monitoring	Psychomotor	3	9

Course Outline

1. Introduction
   a. Air and noise pollutants (indoor and outdoor)
   b. Sources of air and noise pollution (indoor and outdoor)
   c. Greenhouse Effect/Global Warming

d. Ground Level Ozone Pollution
e. Ozone Depletion
f. Environmental impact of EM radiation and Radon
g. Acid Rain
h. Natural Cleansing Process in the Atmosphere
i. Health effects of air and noise pollution

2. Basic Meteorological Processes

a. Atmospheric lapse rate and thermodynamics
b. Wind velocity and wind rose
c. Atmospheric stability
d. Boundary layer concept
e. Effect of Meteorology on Plume Rise and Dispersion

3. Air Quality Regulations

a. Air Pollution Index
b. Air Quality Regulations in Pakistan
c. Air Quality Standards (National and provincial)
d. Other international guidelines such as World Bank, WHO, IFC, ISO and OSHA standards, etc.

4. Air Quality Modeling

a. Types of Plumes
b. Flow Regimes of a Plume
c. Plume Rise
d. Ambient Air Concentration Modeling such as Gaussian Dispersion Models, Plume Dispersion Parameters

5. Technology for Air and Noise Pollution Control

Lab Outline

Air and noise pollution instrumentation and monitoring of PM10, PM2.5, COx, NOx, SOx, noise pollution, indoor pollution, Radon, EM radiation

Text Books (s)

- Noel. D. Nevers, Air Pollution Control Engineering, Second Edition, 1999, McGraw-Hill, ISBN: 0070393672
- Debi Prasad Tripathy, Noise Pollution, 2011, APH Publishing Corporation, ISBN: 8131303403
- C. David Cooper and F. C. Alley, Air Pollution Control: A Design Approach, Fourth Edition,.2010, Waveland Pr Inc, ISBN: 157766678X

REMOTE SENSING **3(2-1)**

Contact Hours	**Credit Hours**
Theory =32	Theory =2
Practical =0	Practical =1
Total =32	**Total =3**

Prerequisites
NIL

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**ANALYZE** and interpret remote sensing data	Cognitive	4	2
2.	**APPLY** remote sensing concepts in solving problems	Psychomotor	3	5

Course Outline

1. Fundamentals of Remote Sensing
- b. History of remote sensing
- c. Electromagnetic radiation
- d. Preprocessing and processing of data
- e. Basic principles of Photogrammetry

2. Sensors
- a. 0, Medium and High Resolution Satellites

3. **Image Rectification and Restoration**
- a. Datum, Projection and Coordinate System
- b. Geometric Correction
- c. Data Mosaicking

4. **Image Interpretation**
- a. Introduction
- b. Interpretation elements

5. **Image Enhancements**
- a. Introduction to digital image processing (DIP)
- b. Perception of colors
- c. Visualization of image data
- d. Color composites
- e. Filter operations (noise removal, edge enhancement)
- f. Contrast Manipulation
- g. Spatial Feature Manipulation (Spatial filtering, convolution, edge enhancement, Fourier analysis)
- h. Multi-Image Manipulation (Spectral ratioing and differencing, density slicing, Indices)

6. **Image Classification**
- 1. Principles of image classification
- 2. Unsupervised Classification
- 3. Supervised Classification

7. **Maps and their cartographic representation**

8. **Microwave Remote Sensing**
9. **Remote Sensing data applications**

Lab Outline

1. Introduction to basic tools of Image Processing Software (e.g. ERDAS Imagine, ENVI, IDRISI etc.)
2. Color composites
3. Layer stacking
4. Various sensors data comparison
5. Feature recognition
6. Visual image interpretation
7. Mosaicking
8. AOI
9. Image enhancement
10. Classification (supervised and unsupervised)
11. Spectral signatures and indices

Text Books (s)

- Lillesand, Thomas, Ralph W. Kiefer, and Jonathan Chipman. Remote Sensing and Image Interpretation. 7th Ed. John Wiley & Sons, 2014.
- Gibson, Paul. Introductory remote sensing principles and concepts. Routledge, 2013, ISBN: 0415196469
- Weng, Qihao. An introduction to contemporary remote sensing. McGraw Hill Professional, 2012., 1st Ed, ISBN: 978007140111
- Campbell, James B., and Randolph H. Wynne. Introduction to remote sensing. Guilford Press, 2011, 5th Ed., ISBN: 9781609181765.
- Jensen, John R. Remote sensing of the environment: An earth resource perspective 2/e. Pearson Education India, 2009, ISBN: 9788131716809
- Mather, Paul M., and Magaly Koch. Computer processing of remotely-sensed images: an introduction. John Wiley & Sons, 2011.4th Ed, ISBN: 9780470742389

ENVIRONMENTAL HEALTH AND SAFETY (3+0)

Contact Hours	**Credit Hours**
Theory =48	Theory =3
Labs =0	Labs =0
Total =48	**Total =3**

Prerequisites

NIL

Course Learning Outcomes (CLOs):
After studying this course, the learners will be able to:-

S.No	Course Learning Outcomes	Domain	Taxonomy level	Program Learning Outcome
1	**Demonstrate** current rules and regulations pertaining to environmental health and safety	Cognitive	3	8
2	**Analyze** and **experiment** safety protocols and equipments in the field of environmental engineering	Cognitive	4	6

Course outlines:

- Basic principles of public health;
- Communicable & non communicable diseases and their control measures.
- Vector and Rodent Born Disease Control
- Introduction to Environmental Health and Safety
- Overview of Occupational Safety and Environmental Protection
- Elements of Occupational Health and Safety Management Systems (OHSAS-18001)
- ISO 14001
- Housing and Institution Hygiene
- Industrial/nuclear hygiene and safety,
- Accident prevention and elimination plans,
- Role of health and safety personnel
- Industrial-nuclear and occupational rules and regulations in Pakistan
- Agricultural Pesticides Rules, and ordinance
- Technologies Applied to Integrated Pollution Control, Hazardous Waste Management
- Radioactivity; transport, storage & use of toxic chemicals-radio nuclides, occupational health programs

Recommended Books:

- Mark A. Friend and James P. Kohn, Fundamentals of Occupational Safety and Health, Sixth Edition, 2014, Government Institutes, ISBN: 978-1605907062.
- Sandy Cairncross and Richard G. Feachem, Environmental Health Engineering in the Tropics: An Introductory Text, Second Edition, 1993, John Wiley & Sons, ISBN: 0471938858.
- Joseph A. Salvato, Environmental Engineering. & Sanitation, 4th edition, 1992, Wiley Interscience, ISBN: 978-0471523772

SEMESTER 7

INTEGRATED WATER RESOURCES MANAGEMENT (3+0)

Contact Hours	**Credit Hours**
Theory =48	Theory =3
Labs =0	Labs =0
Total =48	**Total =3**

Prerequisites

NIL

Course Learning Outcomes:

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

S.No	CLO	Domain	Taxonomy level	PLO
1	**Apply** scientific principles for water resources planning and management	Cognitive	3	7

Contents:

- Basic concepts in water resources
- Surface and groundwater resources of Pakistan

- Water resources consumption in domestic, industrial, agricultural sectors and losses due to seepage, evaporation and evapotranspiration
- Rainwater harvesting
- Planning and development of water resources
- Indus Water Treaty and Water Accord 1991 (IRSA)
- Classification of dams, barrages and head works
- Limnology: phosphorus as the limiting nutrient
- Elementary concept about canal head works, selection of their site and layout, weirs and barrages, various components and functions
- Sedimentation control in dams, rivers and canals
- Canal head regulators, falls, flumes, canal outlets. Cross drainage works: types and functions. Canal lining. Maintenance of irrigation canals. Monitoring of flows-telemetry system
- Design of weirs on permeable foundations, sheet piles and cut off walls
- Definition and types of irrigation. Merits and demerits of irrigation, Indus Basin Irrigation System (IBIS)
- Design of irrigation channels, Kennedy's and Lacey's Theories. Rational methods for design of irrigation channels, comparison of various methods, computer Aided design of irrigation channels
- Irrigation methods (surface, sprinkler, drip) and practices,
- Irrigation scheduling
- Causes and effects of water logging and salinity
- Reclamation of water logged and saline soils, drains and tube wells. Causes and effects of salinity and alkalinity of lands in Pakistan
- Understanding the concepts of drainage, land reclamation, surface drainage, subsurface drainage, cross-drainage structures, disposal of drainage effluents

Recommended Books:

- Iqtidar H. Siddiqui, Irrigation and Drainage Engineering, 2003, Oxford University Press, ISBN: 9780195473568
- Ray K. Linsley, Joseph B. Franzini, and David L Freyberg, Water Resources Engineering, Fourth Edition, 1991, McGraw-Hill, ISBN: 0070380104
- Sharma, R. K. and T. K. Sharma, Text Book of Irrigation Engineering: Irrigation and Drainage, Vol-I to V. 1991, Oxford and IBH Pub. Co., ISBN: 8120405080 (Vol-I)

TECHNICAL WRITING AND PRESENTATION SKILLS 2 (2+0)

Objectives:

- To enhance language skills and develop critical thinking

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the concept of environment	Cognitive	2	11

Contents:

1. 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)
2. Technical Report writing
3. Progress report writing

Note: Extensive reading is required for vocabulary building

Recommended Books: (Latest editions where possible)

- Patterns of College Writing (12th edition) 2012 by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.
- College Writing Skills by John Langan. McGraw-Hill Higher Education. 2004.
- 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).

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)

ENVIRONMENTAL LAWS AND POLICIES **2(2-0)**

Contact Hours Credit Hours

Theory =32	Theory =2
Practical=0	Practical =0
Total =32	**Total = 0**

Prerequisites
Introduction to Environmental Engineering

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	Learn about the means and scope of Environmental Planning and formulation of the Environmental plans for controlling the Environmental issues/problems through national, international and global efforts.	Cognitive		7
2.	Educate on international treaties, protocols, Environmental legislation and policies.	Cognitive		8

Course Outline

1. International Law and Environment: Introduction; History and Structure of International Law**;**
2. State Responsibility in International Law**;**
3. International Conventions and Conservation Strategies Current status of the environment in Pakistan, Conservation strategies (NCS, SPCS).
4. Organizational and Institutional Framework for environmental conservation and management: scope and status in Pakistan.
5. The Pakistan Environmental Protection Act, 1997, its regulations, the Review of IEE/EIA Regulations, 2000, the Environmental Laboratories Certification Regulations, 2001 and the rules,
6. National Environmental Quality Standards (Self-Monitoring the Reporting by Industries) Rules, 2001,
7. Administrative Penalty Rules 2005, Hazardous Substances Rules and the Hospital Waste Management Rules 2000
8. Pakistan Environmental policy 2005; Draft National Environmental Policy; National and Provincial Climate change Policies; France Agreement 2017.

Text Books (s)
1. Review of Environmental Protection Agency Regulations, 2000: (Review of Initial Environment Examination and Environmental Impact Assessment), National Impact Assessment Program, 2014 IUCN Pakistan

2. Environmental Laws and their implementation in Pakistan, Qadar, S. Law Books House, 2000.
3. Ball, S. and Bell, S.Latest Edition. Environmental Law-The law and policy relating to the protection of the Environment. 2nd Ed. London black stone press limited.
4. Barrow, C.J. Latest Edition. Development the Environment: Problems and management. Essexm London.
5. Bimie, P. W., and Boyle, A.E., "International Law and the Environment", Clarendon Press, London, 2009. ISBN: 9780198764229.
6. Hansen, P. E. and Jorgensen, S.E. Latest Edition. Introduction to Environmental management. Development in Environmental modeling. 18: Amsterdam, Elsevier.
7. Pakistan National Conservation Strategy (2000). IUCN, https://www.iucn.org/downloads/pakistan_ncs_mid_review.pdf

INDUSTRIAL AND HAZARDOUS WASTE MANAGEMENT 3(3-0)

Contact Hours	**Credit Hours**
Theory =48	Theory =3
Practical =0	Practical= 0
Total =48	**Total =3**

COURSE OUTCOMES:
Upon successful completion of the course, the student will demonstrate competency by being able to:

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the sources, composition and characteristics of the waste and basic concepts of treatment in terms of combined or individual treatment scheme	Cognitive	2	2
2.	**DISTINGUISH** the waste generation & collection requirement and **ANALYZE** optimum collection treatment mechanism	Cognitive	4	3
3.	**DESIGN** the final disposal/management of	Cognitive	5	4

	chemical or biological sludge generated from treatment			

Course contents:

1. Definitions of industrial and hazardous wastes
2. Types and characteristics of industrial wastes
3. Industrial waste reduction and reuse
4. Waste audits and their types
5. Liquid waste management
6. Waste to energy from Industrial Waste
7. Pollutant types
8. Waste sources from various processes and their composition
9. Waste sources and composition
10. Sample collection and analysis protocol
11. Waste minimization and recycling potential
12. Stream segregation and waste quantification
13. Types of treatment for various waste streams
14. Types of treatment for various waste streams
15. Gaseous wastes and their treatment
16. Most polluting industries in Pakistan and NEQS
17. Environmental regulations and Penalties
18. Case Study of Textile Waste Management+ Field Trip
19. Case Study of Tannery Waste Management + Field Trip
20. Case Study of paper and sugar Mills Waste Management + Field Trip

TEXT AND MATERIAL:

Recommended Books (Latest editions where possible):

- Vivek V. Ranade, Vinay M Bhandari, Industrial Wastewater Treatment, Recycling and Reuse 1st Edition (2014). Elsevier publishers, Netherlands, ISBN: 978-0-08-099968-5
- W. Eckenfelder Jr., Andrew Englande Jr. Industrial Water Quality 4th Edition, 2008, McGraw-Hill Publishers USA
- Industrial Wastewater Management, Treatment, and Disposal, 3e MOP FD-3 (WEF Manual of Practice) 3rd Edition by Water Environment Federation.
- Michael D. LaGrega, Phillip L. Buckingham and Jeffrey C. Evans, Hazardous Waste Management, Reissue Edition, 2010.

ELECTIVE I

Select from the list of elective courses

FINAL YEAR DESIGN PROJECT I **3(0+3)**

SEMESTER 8

CLEANER PRODUCTION TECHNIQUES (2+0)

Course Learning Outcomes (CLOs):
After studying this course, the learners will be able to:-

S.No	Course Learning Outcomes	Domain	Taxonomy level	Program Learning Outcome
1	**Understand** Cleaner Production techniques as the advanced tool for environmental improvement	Cognitive	2	5
2	**Demonstrate** and **Categorize** cleaner production plans and strategies for implementation	Cognitive	4	11

Course outlines:
- Basic concepts of cleaner production and sustainable development;
- Its principles, benefits and phases;
- Introduction to CDMs
- Plans and strategies for implementing CP techniques
- Cleaner production and Eco-efficiencies
- Pollution Prevention and Cleaner Production
- Study of various hindrances and barriers during CP implementation
- Closed loop operations,
- Methodology and framework for clean production
- Global clean production network
- Corporate social responsibility by Industry
- Incentives for CP investment
- Case studies from industry where the methods of cleaner production have been applied.

Recommended Books:

- Kenneth L. Mulholland, Identification of Cleaner Production Improvement Opportunities, 2006, Wiley-Blackwell, ISBN: 0471794406
- Promoting Cleaner Production in Developing Countries: The Role of Development Co-operation, 1995, Organization for Economic Co-operation and Development (OECD), ISBN: 9264146318
- Ruth Hillary, Environmental Management Systems and Cleaner Production, 1997, Wiley-Blackwell, ISBN: 0471966622

- Paul M. Randall, Engineer's Guide to Cleaner Production Technologies, 1997, Technomic Publishing Co., Inc., ISBN: 1566764238
- Cleaner Production: Global Status 2002, United Nations Environment Programme.

ENERGY CONSERVATION AND MANAGEMENT **3(3-0)**

Contact Hours Credit Hours

Theory = 32	Theory = 3
Practical= 0	Practical= 0
Total = 32	**Total = 0**

Prerequisites
Introduction to Environmental Engineering

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Understand** and identify various sorts of energy resources	Cognitive		11

Course Contents:
1. Renewable energy principles;
2. Solar radiation characteristics, measurements and local data. Passive use of solar energy
3. Photovoltaic; Micro-hydroelectric plants;
4. Wind power; Concept and Principles, evaluating potential to use this resource,
5. Biofuels; Ethanol from Biomass;
6. Wave and tidal and ocean thermal energy; Geothermal energy; Energy storage (batteries and fuel cells etc.).
7. Hydrogen from renewable energy sources. Role of energy in Green Economy.
8. Energy conservation and efficient use of energy
9. Energy Inefficiency
10. Clean energy and alternatives sources of energy:
11. Green architecture and green city
12. Energy technology
13. Value engineering and management
14. Energy economic decision making
15. Energy management and conservation:
16. Steps in energy management

Recommended Books:

1. Walisiewicz, M. and Gribbin, J. (1st Edition) 2002, Alternative Energy (Essential Science Series). D K Publishing, New York, USA.
2. Hoffmann, P. Tomorrow's Energy: Hydrogen, Fuel Cells and the Prospects for a Cleaner Planet. MIT Press. (Latest Edition)
3. Cassedy, E.D. Prospects for Sustainable Energy: A Critical Assessment. Cambridge University Press. (Latest Edition)
4. Trivedi, P.R. and Raj, G. Environmental Energy Resources. Akas deep Publishing, New Delhi. (Latest Edition).
5. Kleindorfer, P et al., (Eds.) Energy, Environment, and the economy: Asian perspectives .
6. Cheltenham,UK : Edward Elgar.1996. Leitmann, J. Energy - environment linkages in the urban sector. Washington, D.C.
7. World Bank. 1991. O'Callaghan, Paul W. Energy management .London:McGraw-Hill.1993.

WorldEnergyCouncil.Energyfortomorrow'sworld-actingnow!:WECstatement2000.London:The Council 2000.

ENTREPRENEURSHIP **2 (2+0)**

Objectives:

- To introduce the concept of entrepreneurship as a career and lifestyle choice
- To make student learn about opportunity identification, market assessment, financing and emerging firm, product innovation, technology commercialization, business plan development, strategy and entrepreneurship and managing a growing firm

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the concept of environment	Cognitive	2	10
2.	**UNDERSTAND** the concept of anthropology	Cognitive	2	11

Contents:

- Introduction to entrepreneurship
- Entrepreneurial process
- Business opportunity identification
- Market assessment
- Financing and emerging firm
- Product innovation

- Technology commercialization
- Business plan development
- Strategy and entrepreneurship
- Managing the growing firm

Recommended Books: (Latest editions where possible)

- Small Business and Entrepreneurship by Paul Burns and Jim Dew Hurt
- Entrepreneurial for economic Growth by P. N. Singh
- Entrepreneurship Success by John B. Miner

ELECTIVE II

Select from the list of elective courses

FINAL YEAR DESIGN PROJECT II **3(0+3)**

LIST OF ELECTIVE COURSES

MARINE POLLUTION CONTROL **3(3-0)**

Contents:

- Effects of pollutant discharges
- Oil spills
- Coastal zone management
- Beach erosion
- Channel dredging and changing sea-level on marine environment and control measures
- Modeling for pollution dispersion.
- Study of marine biology (organism, fisheries and mangroves),
- Coastal geology and estuarine ecology.
- Marine resources management. Sea water intrusion.

Recommended Books: (Latest editions where possible)

- Introduction to Earth Systems Science and Global Environmental Change, Fred Mackenzie, Printice-Hall 1998
- Case Studies in Oceanography and Marine Affairs George Brows and Engela Open University, UK 1991
- Ocean Chemistry and Deep Sea Sediments, Open University, UK, 1995
- Sea Water its Composition Properties and Behavior, Evelyn Brown, Engela Collings, 1995

ENVIRONMENTAL NANOTECHNOLOGY 3(3-0)

Course Description

Environmental Nanotechnology provides a broad overview of nanotechnology, discussing the fundamental science of nanotechnology and its applications particularly to environmental fields and generally to engineering, biomedical applications. The course discusses the interdisciplinary nature of nanotechnology and how the different basic sciences merge to create the field.

The course provides a background of the understanding, motivation, implementation, impact, future, and environmental implications of nanotechnology. The course will also discuss specific applications of nanotechnology in environmental solutions, energy production, electronic devices and biomedical fields.

Course Contents

- Introduction.
- Introduction to Environmental aspects of nanoscience and nanotechnology
- Physical and Chemical properties of Nanomaterials
- Methods of Measuring Properties.
- Environmental Implications
- Environmental Applications of Nanomaterials
- Carbon Nanostructures.
- Self-Assembly and Catalysis.
- Organic Compounds and Polymers.
- Biological Materials.
- Nanomachines and Nanodevices.
- Bulk Nanostructured Materials.

Books

- Mark Wiesner , Jean-Yves Bottero*, Environmental Nanotechnology: Applications and Impacts of Nanomaterials,* 1st Edition, McGraw-Hill Education (2007)
- Charles P. Poole, Jr., Frank J. Owens, *Introduction to nanotechnology,* 2003, John *Wiley* & Sons, Inc. ISBN: 978-0-471-07935-4

ENVIRONMENTAL MODELING 3 (3-0)

Objectives:

- To introduce the basic concepts of water quality modeling in river, lakes and estuaries

Contents:

- Introduction
  - Understanding of surface water
  - Modeling of surface water
  - Hydrodynamics
- Water quality and eutrophication
  - Overview
  - Algae
  - Organic carbon
  - Phosphorus
  - Nitrogen
  - Dissolved oxygen
- Mathematical modeling and analysis
  - Mathematical models
  - Model selection
  - Spatial and temporal resolution
  - Statistical analysis
  - Model calibration and validation
- Water quality modeling of rivers
  - Characteristics of rivers
  - Hydrodynamics processes in river
  - Sediments and water quality processes in river
  - River modeling
- Water quality modeling of lakes and reservoirs
  - Characteristics of lakes
  - Hydrodynamics processes in lakes
  - Sediments and water quality processes in lakes
  - Lake modeling
- Water quality modeling of estuaries and coastal waters
  - Tidal processes
  - Hydrodynamics processes in estuaries
  - Sediments and water quality processes in estuaries
  - Estuarine and coastal modeling

Recommended Book:

- Ji, Z. G. (2017). *Hydrodynamics and water quality: modeling rivers, lakes, and estuaries*. John Wiley & Sons.

Note: Contents for the rest of elective courses may be made by the respective universities to fulfill the market needs.

SCHEME OF STUDIES FOR
MASTERS IN ENVIRONMENTAL ENGINEERING

List of Core Courses

S. No.	Course Title	Credit Hours
1	Principles of Environmental Engineering	**3(3-0)**
2	Water Quality Modeling	**3(3-0)**
3	Municipal Solid Waste Principles and Management	**3(3-0)**
4	Physico-Chemical Water Treatment Processes	**3(3-0)**
5	Green Engineering Technologies	**3(3-0)**
6	Air Pollution Control Engineering	**3(3-0)**
7	Environmental Impact Assessment	**3(3-0)**
8	Biological Wastewater Treatment Processes	**3(3-0)**
9	Renewable Energy Resource Engineering	**3(3-0)**
10	Meteorology and Effluent Dispersion	**3(3-0)**

List of Elective Courses

S. No.	Course Title	Credit Hours
1	Water Resource Engineering	**3(3-0)**
2	Ecology and Risk Assessment	**3(3-0)**
3	Occupational Health and Safety Engineering	**3(3-0)**
4	Water Supply and wastewater Collection Systems	**3(3-0)**
5	Marine Pollution Monitoring and Control	**3(3-0)**
6	Modeling of Environmental Systems	**3(3-0)**
7	Agricultural Pollution Control Engineering	**3(3-0)**
8	RS and GIS Application in Environment	**3(3-0)**
10	Environmental Analytical Techniques	**3(1-2)**
11	Environmental Remediation Engineering	**3(3-0)**
14	Environmental Laws and Policies	**3(3-0)**
15	Watershed Management	**3(3-0)**
16	Anaerobic Wastewater Treatment	**3(3-0)**
17	Membrane Technology for Water and Wastewater Treatment	**3(3-0)**
18	HAPs Characterization and Control	**3(3-0)**
20	Principles of Environmental Engineering	**3(3,0)**
21	Research Methodology	**3(3-0)**

Degree Requirements: Students must pass a minimum of 24 credit-hours coursework and 6 credit-hours of their research work in the form of thesis if deem fit.

List of Core Courses: In total, there are 9 core courses; out of these, minimum of 5 courses are to be taken by the students.

Elective Courses: Fifteen elective courses have been formed keeping in view the needs in the field of Environmental Engineering in the country. Out of these, a student has to pass requisite number of courses to complete his total 24 credit hours of coursework.

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CORE COURSES

BIOLOGICAL WASTEWATER TREATMENT PROCESSES 3(3,0)

Nature of Wastewater, Micro-organisms and Pollution Control, Microbial Oxygen Demand, Basic Treatment Processes, Sedimentation, Secondary (Biological) Treatment, The Role of Organism, Anaerobic Heterotrophic Micro-organisms, Aerobic Heterotrophic Micro-organisms, Autotrophic Micro-organisms, Assessing Treatability, Toxicity, and Biodegradability, Fixed-Film Reactor, Activated sludge, modes of operation, sludge problem, Natural Treatment System, Sludge Treatment and Disposal, Indicator Organisms.

RECOMMENDED BOOKS

1. C. P. Leslie Grady, Jr., Glen T. Daigger, Nancy G. Love, Carlos D. M. Filipe Biological Wastewater Treatment, 3rd Edition, 2011, CRC Press
2. N.F. Gray, BIOLOGY OF WASTEWATER TREATMENT, 2nd Edition, 2005, Imperial College Press, UK
3. M. Henze, Mark C.M. van Loosdrecht, G.A. Ekama, D. Brdjanovic, Biological Wastewater Treatment, 2008, IWA publishers, USA

GREEN ENGINEERING TECHNOLOGIES 3(3,0)

The Green Engineering Technologies course will serve as a catalyst for the organic growth of sustainable systems engineering concepts. Green Engineering can be defined as environmentally conscious attitudes, values, and principles, combined with science, technology, and engineering practice, all directed toward improving local and global environmental quality. This course is consistent and compatible with sound engineering design principles and is highly interdisciplinary with team-based projects. Introduction to global environmental issues, Concepts of Life Cycle Assessment and the Triple Bottom Line

(environment, economics, and society) with a focus on engineering design, Green Systems and Environment,Introduction to fundamentals of applications of green engineering and ecosystem based adaptations, Ecosystem based instruments and approaches, Industrial Ecology-Technology Environment Interaction, Mainstreaming Environment in Development, Concepts of environmental and environmentally conscious design and manufacturing problems, Green Technologies for Energy Production: Opportunities in Control of Carbon emissions, Green Technologies for Process Industry, Green Technologies for Specific Applications, Green Technology and Sustainable Development,

Recommended Books

1. Marteel-Parrish, A. E. and Abraham, M. A. 2013, Green Chemistry and Engineering: A Pathway to Sustainability, John Wiley & Sons, Inc, Hoboken, NJ. doi: 10.1002/9781118720011
2. Singh, Ritu, Kumar, Sanjeev, 2017, Green Technologies and Environmental Sustainability, Springer.
3. Dustin Mulvaney 2010, Green Technology: An A-to-Z Guide, Sage Publications Inc. Available at: http://works.bepress.com/dustin_mulvaney/4/

HAPs CHARACTERIZATION AND CONTROL 3(3-0)

Definition of Hazardous Air Pollutants (HAPs), HAPs emissions by source category, Key Physical and Chemical Properties, HAPs Characterization, Measurement Methods of HAPs in ambient air, In-plume measurement of fugitive and point source emissions, Atmospheric transformations products of 1990 Clean Air Act title-III HAPs, Inventorying HAPs at industrial facilities, HAPs Associated Health Risks, Control Strategies and Applicable Technologies, Thermal Incineration, Catalytic Incineration, Flares, Carbon Adsorption, Absorption, Enhanced Fine Particulate Control for reduced Air Toxic Emissions, Fabric Filters, Electrostatic Precipitators, Venturi Scrubbers, Design and Cost of HAPs Control Techniques, Integrated approach for ambient air toxic impact analysis, Models for risk assessment management and design.

Recommended Books

1. Managing Hazardous Air Pollutants by Winston Chow and Katherine K Connor, CRC Press, 1993.
2. Rapid Guide to Hazardous Air Pollutants, Howard J. Beim, Jennifer Spero, Louis Theodore, Wiley, 1997
3. Hazardous Air Pollutants, Assessment, Liabilities and Regulatory Compliance by Jeffrey W. Bradstreet, Noyes Publishers,1996
4. Hazardous Air Pollutants Handbook: Measurements, Properties, and Fate in Ambient Air by Chester W. Spicer, Sydney M. Gordon,

Michael W. Holdren, Thomas J. Kelly and R. Mukund, CRC Press, 2002
5. Control Technologies for Hazardous Air Pollutants by Michael K. Sink, NSCEP, USEPA, 1991.

RS and GIS Application in Environment 3(3,0)

The course will present and assess the fundamental concepts of GIS and remote sensing technologies in the contest of environmental engineering.Topics include the physical basis for remote sensing, remote sensing systems, digital image processing, data structures, database design, and spatial data analysis.Examples of applications of GIS and remote sensing technologies to various environmental applications with a particular focus on sustainable practices will be used throughout the course.Recent technical papers on GIS and RS applications to environmental and sustainability issues will be reviewed in class and as part of homework assignments and class discussion. Multiple GIS exercise will be used in class and as assignments and presentations. The course will include discussion and review of public policy and initiatives on environmental and sustainable development issues relative to current developments in technology and applications in the overall fields of GIS and remote sensing.

- Introduction to GIS and Remote Sensing
- Using ArcGIS
- History of Remote Sensing Systems
- Case study examples of environmental applications
- Overview of Current Remote Sensing Systems
- Development of GIS layers and atributes
- Text and Table linking to GIS layers
- Multispectral remote sensing applications
- Image interpretation
- Area and regional analysis with GIS
- Case studies of Environmental Sustainable applications
- Remote Sensor System selection criteria and applications

Recommended Books

1. Srivastava**, P.K.,** Mukherjee**, S.,** Gupta**, M.,** Islam**, T.** (Eds.) 2014, Remote Sensing Applications in Environmental Research, Springer Publishers Germany.
2. Andrew Skidmore, 2002, Environmental Modelling with GIS and Remote Sensing, CRC Press.
3. Abhisek Santra, 2016, Remote Sensing Techniques and GIS Applications in Earth and Environmental Studies, I SBN13:

9781522518143;EISBN13:9781522518150
URL:www.igi-global.com/book/remote-sensing-techniques-gis-applications/165961

PRINCIPLES OF ENVIRONMENTAL ENGINEERING 3(3-0)

Natural and anthropogenic factors affecting the environment, Global, regional and national environmental issues, Global environmental issues; acid rain, global warming, ozone depletion, national environmental problems related to human, wastes, industrial wastewaters and solid wastes, water, air and radiological pollution. Population and resource utilization, Environmental degradation processes and environmental pollution. Effects of pollution on human health and environment. Sustainable development, definition and inter-relationship between its components. Strategies for sustainable development. Key elements of Pakistan National Conservation Strategy. International environmental conventions and treaties. Introduction to codes and ethics of environmental engineering Review of national and international codes and ethics in environmental engineering Relationship between ethics and human rights and their importance in human settlements and societies.

RECOMMENDED BOOKS

1. Mackenzie, L. 2008. Principles of Environmental Engineering and Science. McGraw Hill Series in Civil and Environmental Engineering.
2. Vesilind, P.A., Morgan, S.M., Heini, L.G. 2010. Introduction to Environmental Engineering. 3rd Edition. Cengage Learning.
3. Maczulak, A.E. 2011. Environmental Engineering. Infobase Publisher.
4. Srinivasamn. 2009. Environmental Engineering. PHI Publisher.
5. Reible, D.D. 1999. Fundamentals of Environmental Engineering. Lewis Publishers.

Water Quality Modeling 3(3-0)

Basic concept of modeling; Hydrological considerations in water quality modeling; Low flow frequency analysis; Sources of pollution and types of wastes; Point and non-point sources; General mathematical formulation of water quality models for streams and rivers, reservoirs, estuaries; Biological oxygen demand (BOD); Dissolved oxygen (DO), Bacterial decay and nitrification; Model calibration and verification; Application of river models for water quality management;

RECOMMENDED BOOKS

1. Thomson, E.V. 1987. Principles of Surface Water Quality Modeling and Control. Happer and Row Publishers New York.
2. Manivanan, R. 2012. Water Quality Modelling: Rivers, Streams and Estuaries. New India Publishing Agency.

3. Omole, D. 2010. Water Quality Modelling. Lambert Academic Publishing.
4. Koios, E.R. 2012. Water Quality Modelling. Beta Script Publishing.

Municipal Solid Waste Priciples and Management 3(3-0)

Solid waste: History, sources, classifications and characteristics; Collection of solid waste; Types of collection vehicle and vehicle routing, transfer and transport, design of transfer facility, onsite handling and storage; Integrated solid waste management and its components; Industrial waste: Sources, composition and management; Physical, chemical and biological properties of solid waste; Physical, chemical and biological transformations of solid waste; Hazardous waste: Sources, properties and health impacts; Transformation and management of hazardous waste; Solid waste generation and collection rates; Disposal of solid waste; Landfill: Overview, planning, design, classification, landfill construction techniques, landfill siting consideration, reactions and process/generation of gases, control of landfill gases, management of landfill gases, leachate management, settlement of landfills, monitoring of landfills and preliminary design; Composting: Types, methods and design of composting facilities; Incineration and design of incinerator; Bio-gasification and design of biogas plants; Socio-economic evaluation of solid waste management systems.

RECOMMENDED BOOKS

1. Tehobanoglous, G. 1993. Integrated Solid Waste Management. Mcgraw Hill
2. Vesilind, P.A., Worrel, W.A. 2011. Solid Waste Engineering. 2nd Edition. Cengage Learning.
3. Theisen, H., Vigil, S.A. 1993. Integrated Solid Waste Management; Engineering Principals and Management Issues. McGraw-Hill, USA.
4. Wang, L.K., Pereira, N.C. 2012. Solid Waste Engineering and Management. Humana Press.
5. Christensen, T. 2011. Solid Waste Technology and Management. John Willy, USA.

Physico-Chemical Processes in Environmental Engineering 3(3-0)

Water treatment: Objectives, water related diseases, sources and characteristics; Water treatment plant: Types, components, sources and design basis; Reaction kinetics: Types of chemical reactions. Rate of reactions, reactor design, mass transfer models of CSTR and plug flow reactors; Coagulation: Principal, types of coagulants, stability of colloidal matter, mechanisms for coagulation, chemistry, kinetics and design of coagulation systems; Flocculation: Types, chemistry kinetics and design of flocculation systems; Sedimentation: Types and sedimentation basins, design of sedimentation basins; Floatation systems; Filtration: Theory,

types, slow sand filtration, rapid sand filtration, deionised exchange, mechanisms of water filtration, transport and attachment step, designing of water filtration systems, pilot plants; Disinfection: Types and design; Adsorption: Types, principals and application in the industry, kinetics of adsorption and adsorption isotherms; Ion exchange and demineralization: Process, mechanisms, types, design of softening and demineralization systems; Membrane processes: Dialysis, reverse osmosis; Gas transfer: Theory and application, diffuse aeration systems: Taste and odour: Sources and control; Corrosion: Sources and control, organic and inorganic removal; Water treatment facility design

RECOMMENDED BOOKS

1. Tom, D., Raynolts, Richard, P.A. 1996. Unit Operations and Processes in Environmental Engineering. PWS Publishing Company.
2. Mwh. 2012. Physico-chemical Processes in Environmental Engineering. John Wiley & Sons, USA.
3. Kawamura, S. 1990. Integrated Design of Water Treatment Facilities. Wiley Inter-science, NY.
4. Metcalf and Eddy. 2004. Wastewater Engineering by McGraw Hill.
5. Kawamura, S. 1990. Integrated design of water treatment facilities. Willy Inter Science, NY.
6. Weber Jr., W.J. 1992. Physico-chemical processes for water quality control. Jhon Willy and Sons.

Air Pollution Control Engineering 3(3-0)

Overview of air pollution and wastes and their impact, Definition, types and characteristics of pollutants, Effects of air pollution, Laws and regulations to control air pollution, Emission estimates, Sources of Pollution Internal combustion engines, Power generation plants, Chemical industries, Transformations and Transport of Air Pollutants, Reactions and scavenging processes, Diffusion etc. as a means of transport, Measurements and Modeling of Air Pollution, Meteorology Models to estimate air pollution concentration, Control Methods for Different Types of Air Pollutants, Primary particulate matter sampling and control ,Selection, Evaluation, and Application of Control Devices, Design of Cyclones, Scrubbers, Filters, Electrostatic Precipitators (ESP) & Adsorption, Analysis and control of volatile organic compounds (VOC's), Control of SOx and NOx emissions, Emissions and their Control from Industrial Processes, Design of Furnaces and boilers, Air emission control strategies for the power industry, Different strategies used for emission control from furnaces, boilers and engines.

RECOMMENDED BOOKS

1. Lawrence, K.W., Pereira, N.C., Hung, Y. 2004. Air Pollution Control Engineering. Humana Press.
2. Mycock, G.C., McKenna, J.D., Theodore, L. 1995. Handbook of Air Pollution Control Engineering and Technology. CRC Press.
3. Nevers, N.D. 2010. Air Pollution Control Engineering. McGraw Hill Publisher.
4. Rao C.S. 2006. Environmental Pollution Control Engineering. 2nd Edition. New Age International.
5. Davis, W.T. 2000. Air Pollution Engineering Manual. Air & Waste Management Association.

Environmental Impact Assessment 3(3,0)

Environment and environmental issues; Environmental economics; Environmental organizations, legislations, standards; ISO-14000 and Environmental Quality Standards (NEQs); Pollution charges. Components for environmental assessment: Screening, scoping, baseline study, mitigation, monitoring, prediction and auditing; Environmental impact methodology; Environmental impact Assessment (EIA); Introduction, overview, principles and purposes, significance to the society, cost and benefits, main stages in EIA process, law, policy and institutional arrangements for EIA systems, public involvement, screening, scoping, impact analysis, mitigation and impact management, reporting, review of EIA quality, decision-making to implement the project, project implementation and follow up; EIA project management; Social impact assessment (SIA); National Environmental Quality Standards (NEQs) for air, liquid, solids, and noise; Role of quality assurance and quality control in environmental analysis; EIA Regulations 2000 of Pakistan; Introduction to Environmental Management (EM): Why, how, what, who; Legislative background to environmental management; Introduction to EM tools; Integrated pollution control; 3 tier approach to EM; Environmental management systems: ISO, LCA; Public involvement in environmental management.

RECOMMENDED BOOKS

1. Hosetti, B.B. 1998. Environmental Impact Assessment and Management. Daya Publishing House.
2. Morgan, R.K. 2002. Environmental Impact Assessment: A Methodological Perspective. Kluwer Academic Publications.
3. Glasson, J., Therivel, R., Chadwick, A. 2005. Introduction to Environmental Impact Assessment. Routledge Publisher London.
4. Morris, P., Therivel, R. 2009. Methods of Environmental Impact Assessment. Taylor & Francis Publisher.
5. Ryding, S. 1994. Environmental Management Handbook. IOS Press.

6. Calow, P.P. 2009. Handbook of Environmental Risk Assessment and Management. John Willy Inc.

Renewable Energy Resource Engineering 3(3-0)

Introduction to renewable energy resource: Solar energy, wind energy, hydropower, geothermal, hydrogen and nuclear energy, Need for alternative energy sources, Overview of energy conservation, Thermodynamic limitations, Basics of solar energy: Heat transport and storage, Photovoltaic cell technology, Active and passive solar design, Large scale solar Energy generation, Energy storage systems, Wind energy: How windmills work, Wind energy: Production facilities, Hydroelectric power: Feasibility and risks, Comparative review of sustainable energy technologies, Economic aspects of renewable energy, Temporal aspects of renewable engineering.

RECOMMENDED BOOKS

1. Twidell, J., and Weir, T. 1986. Renewable energy resources. Taylor and Francis Publication, USA.
2. Smith, Z.A., and Taylor, K.D. 2008. Renewable and alternative energy resources: A reference handbook. ABC-CLIO Publications
3. Craddock, D. 2008. Renewable energy made easy: Free energy from solar, wind, hydropower, and other alternative energy sources. Atlantic Publishing Company
4. Tiwari, G.P., and Mishra, R.K. 2011. Advanced renewable energy sources. Royal Society of Chemistry

METEOROLOGY AND EFLUENT DISPERSION 3(1,2)

Introduction to Meteorology, Air pressure, winds, and circulation, Atmospheric Stability, Temperature and Moisture, Meteorological factors affecting pollution dispersion; Physical principles of atmospheric transport processes. Variation of pollutant transport in time and place, Local and regional concentrations of pollutants, Steady state solution of the diffusion equation; Gaussian plume model GPM) (for point, line and area sources; Calculation of plume rise; Stack design Plume trajectory analysis and long range transport; Tracer Experiments Emission inventories; Dispersion of pollutants released into water bodies and soil; Pollutants dispersion modeling in air and surface waters. Eulerian and Lagrangian dispersion modeling concepts. Micro, Regional and Meso-scale Meteorological Model and GPM using computational tools.

Recommended Books

1. Beychok, Milton R. (2005). Fundamentals of Stack Gas Dispersion, 4th Edition.
2. Arya, S. Pal (1998). Air Pollution Meteorology and Dispersion, 1st Edition, Oxford University Press

3. Turner, D.B. (1994). Workbook of Atmospheric Dispersion Estimates: An Introduction to Dispersion Modeling, 2nd Edition, CRC Press.
4. Pielke, Roger A. (2001). Mesoscale Modeling, 2nd Edition, Elsevier.
5. Cooper, J.R., Randle, K. and Sokh, R.G (2003). Radioactive Releases in the Environment, 1st Edition, John Wiley & Sons.
6. Perianez, Raul (2005). Modelling the dispersion of radionuclides in the marine environment: an introduction, 1st Edition, Springer.

ELECTIVE COURSES

Bioreactor, Biotechnology for Environment 3(3-0)

Concept and scope of environmental chemistry; Chemical reactions, kinetics and mechanism concerning to organic and inorganic pollutants; Fundamentals of aquatic, atmospheric and soil chemistry; Fate of pollutants in environment, their sources and toxic actions; Acid rain and chemistry of acid rain reactions; Greenhouse effect and its effects on biological systems; Ozone chemistry, its causes and adverse effects on environment; Physical and chemical properties of water, wastewater, air and soil; Acid-base equilibrium, chemical kinetics, oxidation-reduction and solubility reactions; Mechanism of coagulation, adsorption, precipitation, absorption, disinfections; Persistent organic pollutants (POP's); Nuclear chemistry and biochemistry: Basics, classification, nomenclature, morphology, physiology and growth mechanisms of microbes, influence of environmental factors on growth and distribution of microbes. Historical perspective of environmental microbiology; Microbial growth and nutrition; Influence of environment on growth and measurement of growth; DNA structure and replication; Protein synthesis; Microbial metabolism; Microbiology of terrestrial environments, aquatic microbiology, aero-microbiology and food microbiology; Biogeochemical cycles of C, N, P, and S with special emphasis on their environmental impact; Biodegradation and bioremediation of organic and inorganic pollutants.

RECOMMENDED BOOKS

1. Manaha, S. E. 2000. Environmental Chemistry. Lews Publisher London.
2. Britten, G. 1994. Wastewater Microbiology. Willy Inter-science New York
3. Lester, J.N., Birkett, J.W. 1992. Microbiology and Chemistry for Environmental Scientists and Engineers. E & FN Spon.
4. Hernandez-Esparza, J.G., Doria-Serrano, M., Fregoso-Infante, C., Singh, M.M. 2008. Environmental Chemistry. Ibanez Springer, Germany.
5. Girard, J.E. 2005. Principles of Environmental Chemistry. 1st Edition, Jones and Barlett, USA.

6. Andrews, J.E., Brimblecombe, P., Jickells, T.D., Liss, P.S., Reid, B.J. 2004. .An Introduction to Environmental Chemistry. 2nd Edition. Blackwell Science, UK.
7. Maier, F.M., Pepper, I.L., Gerba, C.P. 2009. Environmental Microbiology. 2nd Edition, Academic Press, London, UK

Wastewater Engineering and Design 3(3-0)

Wastewater collection and management system: Components of wastewater flows; types of collection systems, sewer appurtenances and design criteria, design of septic tanks; Design of wastewater collection infrastructure; Hydraulics of sewage collection systems; Analysis and selection of wastewater flow rates; Preliminary design of wastewater treatment plants; Principals and design of aerobic bioreactors; Conventional wastewater treatment process; Design of screening chambers; Design of grit and oil removal chamber; Design of flow equalization tank; Design of primary clarifier/sedimentation tank; Design of fixed and attached growth systems; Design of activated sludge treatment plant; Design of extended aeration plants; Design of biological contractor plants; Design of trickling filters; Design of membrane of bioreactors; Design of secondary clarifiers; Design of tertiary treatments; Disinfection, ozonation, nitrification and de-nitrification; Principals of aerobic biological treatments; Design of waste stabilization ponds; Design of aerated lagoons; Principal and design of aeration; Design of constructed wetlands; Design of an aerobic wastewater treatment plants; Reuse options of treated wastewater effluent

RECOMMENDED BOOKS

1. Wastewater Engineering by Metcalf & Eddy (2004) McGraw Hill
2. Davis, M. 2010. Water and Wastewater Engineering. McGraw Hill.
3. Karia, G.L., Christian, R.A. 2006. Wastewater Treatment: Concepts and Design Approaches. PHI Publishers.
4. Russell, D.L. 2006. Practical Wastewater Treatment. John Willy and Sons.
5. Punmia, B.C. 1998. Wastewater Engineering. Laxmi Publications.

Water Resources Engineering 3(3-0)

Hydrological processes; Watersheds: Types and distribution of precipitation; Water losses; Flow in stream, river, estuaries, lakes and reservoirs; Ground water flow and water exploration techniques; Flood and drought management; Water conservation and harvesting; Water quality and watershed management; Water flow measurements & hydraulics; Sustainable development; Introduction to hydrological cycle; Water resources and their role, limits to water availability, water consumption, water pollution, water shortage problem and solution, improving water productivity, water conservation practices; Integrated management of

coastal and marine resources; Wetlands resources; Irrigation resources: Sustainable aquaculture practices; Flood and draught management; Government policies and programmes; Dams, barrages and their environmental impacts on farm water management; Recycling and re-use of wastewater as a resource. Indus Water Treaty 1960; Indus Water apportionment Accord 1991, relevant intuitions and authorities.

RECOMMENDED BOOKS

1. Mays, L.W. 2010. Water Resource Engineering. John Willy & Sons Inc.
2. Jerrik, B.S. 2011. Water Resource Engineering. Part Press.
3. Duggal, K.N., Soni, J.P. 2005. Elements of Water Resource Engineering. New Age International Publishers.
4. Challa, S.N.M. 2002. Water Resource Engineering: Principals and Practices. New Age Publishers.

Ecology and Risk Assessment 3(3-0)

Introduction, principles and concepts of ecosystem; Energy in ecosystem; Biogeochemical cycles; Principles pertaining to limiting factors; Principles and concepts at the community and population levels; Species in ecosystem; Devolution and evolution of ecosystem; Models in ecology; Freshwater ecology; Marine ecology; Estuarine ecology; Terrestrial ecology; Concepts and principles in sustainable development and biodiversity; Habitat damage assessment; End point definition; Quantification of uncertainty; Predictive risk assessment: Exposure, organism level effects; Case studies

RECOMMENDED BOOKS

1. Suter, G.W. 2007. Ecological Risk Assessment. CRC Press.
2. Odhum, E.P., Barrett, G.W. 2005. Fundamentals of Ecology. Thomson Brooks/Cole Publisher.
3. Kangas, P.C. 2004. Ecological Engineering. Principals and Practices. Lewis Publishers
4. Matlock, M.D., Morgan, R. 2011. Ecological Engineering Design: Restoring and Conserving Ecosystem. John Willy & Sons Inc.

Occupational Health and Safety Engineering 3(3-0)

Principles of public health; Introduction and basic concept of environment related health problems; Public health issues; Communicable and non-communicable diseases; Water borne, air borne, food borne and sanitation related diseases and control measures; Occupational health; Human exposure and health impact prevention and control; Industrial pollution and safety plans; Accident prevention procedures, safety principles and practices; Standards of occupational health and safety; Occupational health and safety in Pakistan; Labour code of Pakistan (1986); Industrial and occupational rules and regulations in Pakistan;

Trans-boundary and global health concerns; Industrial hygiene and safety; Accident prevention and elimination plans; Fire protection techniques; Safety equipments.

RECOMMENDED BOOKS

1. Yassi, A., Kjelllström, T., de Kok, T., Guidotti, T.L. 2001. Basic Environmental Health. 1st Edition. Oxford University Press New York, USA.
2. Koren, H. 1980. A Handbook on Environmental Health and Safety: Principals and Practices. Pergamon Press Inc. USA.
3. Caeneross, S. 1993. Environmental Health Engineering. Willy Interscience.
4. Woodside, G., Kocurek, D.S. 1997. Environmental, Safety, and Health. John Willy & Sons Inc.

Water Supply and Wastewater Collection Systems 3(3-0)

Water supply and wastewater collection systems. Estimates of water demand and wastewater flows. Water consumption, factors affecting water consumption, variation in water consumption. Fire demand. Sources of wastewater. Wastewater flow rates and variations. Design period. Methods for estimation of design population. Design flows for water supply and wastewater systems. Water and wastewater quality parameters. Drinking water quality and human health. Water quality guidelines and standards. WHO guide line for drinking water quality. Water source. Initial investigation for selecting water source. Design and construction of tube wells. Well troubles and their solution. Water collection systems for surface water sources. Water transmission and distribution system. Components, layouts. Hardy cross method for pipe network analysis. Design of water distribution systems, construction, testing and commissioning of distribution systems. Overhead reservoirs, their function, location and capacity. Different varieties of water supply pipes. Valves and fire hydrants used in water supply systems. Sewer systems and their layout. Sanitary and storm sewers. Sewer appurtenances. Hydraulics of sewers. Design of sanitary and storm sewers. Design of wastewater pumping stations. Loads on sewers. Sewer pipes and beddings. Layout of sewers.

RECOMMENDED BOOKS

1. Lal, D.L., Upadhyay, A.K. 2009. Water Supply and Wastewater Engineering. S.K. Kataria and Sons.
2. Tchobanoglous, G. 2003. Wastewater Engineering. John Willy and Sons Inc.
3. Folwell, A.P. 2012. Water Supply Engineering: The Designing, Construction and Maintenance of Water Supply Systems. Hard Press Publishing.

4. Gould, E.S. 2012. The Elements of Water Supply Engineering. Hard Press Publishing.

Marine Pollution Monitoring and Control 3(3-0)

Effects of pollution discharges, oil spills, coastal development, beach erosion, channel dredging and changing sea-level on marine environment and control measures, modeling for pollution dispersion. Study of marine biology (organism, fisheries and mangroves), coastal geol ogy and estuarine ecology. Marine resources management. Sea water intrusion.

RECOMMENDED BOOKS

1. Hofer, T.N. 2008. Marine Pollution: New Research. Nova Science Publisher.
2. Clark, R.B., Frid, C., Attrill, M. 2001. Marine Pollution. Oxford University Press.
3. Hassan, D. 2006. Protecting the Marine Environmen from Land Base Source of Pollution. Ashgate Publishing.
4. Chapra, S.C. 2008. Surface Water Quality Modelling. Waveland Press.

Modeling of Environmental Systems 3(3-0)

Basic concepts, definitions and types; Environmental systems modeling, objectives and choices; Sensitivity analysis and sources of error; Introduction to numerical methods, reaction type and orders of reactions; Conservation of mass, energy and momentum; River/stream quality; Development of models; Water quality models of rivers, lakes, reservoirs, estuaries; Contaminants transport models for groundwater and soil, air pollution dispersion models; Noise pollution models in urban centers; Environmental planning models.

RECOMMENDED BOOKS

1. Weber, W.J., Digiamo, F. 1995. Process Dynamics in Environmental System. Wiley Interscience.
2. Ford, A. 2009. Modelling the Environment. Island Press, Washington DC.
3. Webber, W.J. 2001. Environmental Systems and Processes: Principals, Modelling and Design. Willy Interscience.
4. Michael, L.D., Winebrake, J.J. 2000. Dynamic Modelling of Environmental Systems. Springer-Verlag

Agricultural Pollution Control Engineering 3(3-0)

Pre-historic agricultural land use and environmental impacts; Environmental quality impacts and risks of nutrient pollution; Fertilizers as a source of pollution and control measures; Nitrate pollution in soil and ground water and eutrophication; Management factors to reduce fertilizer

pollution; Agricultural management practices and accelerated soil erosion; Agro-ecosystem impacts from pesticides; Mechanisms for human and environmental exposure to pesticides: drift, runoff, leaching, and occupational exposure; Water contamination, toxicity and safety measures; Environmental impacts of intensive tillage; Carbon loss, effects of erosion on downstream or downwind ecosystems; Practical solution to soil erosion; Field and crop based control strategies of erosion; Soil quality impacts of intensive tillage; Genetically modified organisms (GMOs): Risks and benefits; Herbicide, insecticides and antibiotic resistant crops. Environmental quality risks of transgenic organisms; Emergence of contemporary agri-environment policy; Adoption of sustainable farming practices.

RECOMMENDED BOOKS

1. Merrington, G. 2002. Agricultural Pollution: Environmental Problems and Solutions. Taylor and Francis.
2. Scheirling, S.M. 1995. Overcoming Agricultural Pollution of Water. World Bank Publications.
3. Shortle, J.S., Abler, D.G. 2001. Environmental Policies for Agricultural Pollution Control. CABI Publishing.
4. Gandhi, G., Salpekar, A. 2010. Agricultural Pollution. Jnanada Prakashan Publisher.

Remote Sensing and GIS **3(3-0)**

Introduction to geo-informatics; Resources of information; Photogrammetric surveying; Aerial and satellite photogrammetry; Global positioning system (GPS), Fundamentals of satellite systems; Navigational and earth satellites; Positioning systems GPS/Galileo; Integrating GPS data in GIS; Fundamental of GIS, data analysis and output; GIS applications in environmental problems; Fundamentals of remote sensing; Satellite imageries, image processing and interpretation; Physical basis of remote sensing, sensors, platforms, resolutions; Image processing techniques; Classification and digital mapping; Spatial data types and acquiring considerations, Data models and structures; Projections and transformations; Attribute-based operations and spatial analysis. .

RECOMMENDED BOOKS

1. Kennedy, M. 2002. The Global Positioning System and GIS. 2nd Edition. Taylor & Francis, New York.
2. Thomas, M., Lillesand, Kiefer, R.W. 2005. Remote Sensing and Images Interpretation. 5th Edition. John Wiley & Sons, Inc.
3. Bhatta, B. 2011. Remote Sensing and GIS. Oxford University Press.
4. Kumar, S. 2005. Basics of Remote Sensing and GIS. Firewall Media.

5. Mesev, V. 2007. Integration of GIS and Remote Sensing. John Willy & Sons Inc.

Applied Mathematics for Environmental Engineers 3(3-0)

Error analysis and computer arithmetic; Linear systems of algebraic equations; Solution of large system of linear algebraic equations; Nonlinear algebraic equations; Finite difference; Numerical differentiation and integration laws of probability; Conditional probability; Measures of central tendency and measures of dispersion; Continuous random variable and its probability density function; Functions and their approximation to poisson distribution; Sampling and estimation; Statistical tests; Regression analysis; Analysis of variants; Design of experiments

RECOMMENDED BOOKS

1. Strauss, M.J., Bradley, G.L., Smith, K.J. 2002. Calculus. Prentice Hall, USA.
2. Folland, G.B. 2002. Advanced Calculus. First edition. Prentice Hall, USA.
3. Ervin, Kreyszing, E. 2011. Advanced Engineering Mathematics. Jhon Willy and Sons.
4. Hritonenko, N., Iatsenko, I.P., Yatsenko, Y. 2003. Applied Mathematical Modelling of Environmental Problems. Kluwer Academic Publishers.

ENVIRONMENTAL ANALYTICAL TECHNIQUES 3(1-2)

Basic concepts regarding solution preparation; Environmental sampling methods and sample preservation; Basic concepts regarding environmental analysis; Instrumental techniques for environmental analysis; Sample preparation, principle, application, instrumentation; Advantages and disadvantages of the instrumental techniques including noise meter, gas analyzer, gas chromatography (GC); High performance liquid chromatography (HPLC), Ion exchange and gel exclusion chromatography; Atomic absorption spectrophotometer; Inductively coupled plasma (ICP); Polymerase chain reactions and gel electrophoresis

RECOMMENDED BOOKS

1. Lee, Y., Lee, S.C. 2001. Advanced Analytical Techniques and Application. Elsevier Publications.
2. Hochachka, P.W., Mommsen, T.P. 1994. Analytical Techniques. Elsevier Publications.
3. Zhang, C. 2007. Fundamentals of Environmental Sampling and Analysis. John Willy & Sons Incl.

Environmental Remediation Engineering 3(3-0)

Soil and water/groundwater pollution due to biological, chemical and physical entities; Mobility, bioavailability and toxicity of contaminants in soils; Risk assessment approaches to contaminated sites; Remediation and treatment of contaminated land forms along with the issues associated with the treatment; Reuse and land application of liquid and solid wastes; Pollution control methodologies including various treatment and remediation technologies; Specific case studies relating to environmental remediation; Dust-related contaminants (asbestos); Coastal acid-sulfate soils; Acid mine drainage and bioaccumulation of toxins

RECOMMENDED BOOKS

1. Suthersen, S.S. 2005. Insitue Remediation Engineering. CRC Press.
2. Suthersen, S.S. 1997. Remediation Engineering: Design Concepts. CRC-Lewis Press.
3. Wise, D.L. 2000. Remediation Engineering of Contaminated Sites. M. Dekkar Publisher.
4. Chen, F.U. and Morris, M.D. 2000. Soil Engineering: Testing, Design and Remediation. CRC Press.

Environmental Chemistry and Microbiology 3(3-0)

Contents:

Modul-1: Chemistry

- Physical and Chemical Properties of Water, Wastewater, Air and Soil.
- Acid- base Equilibrium
- Chemical Kinetics
- Oxidation-Reduction and Solubility Reactions.
- Mechanisms of Coagulation, Adsorption, Precipitation, Absorption and Disinfections.
- Persistent Organic Pollutants (pop's).
- Nuclear Chemistry and Biochemistry.
- Hardness, Alkalinity, Buffer Solution
- pH-PC diagram,
- Endothermic and Exothermic reactions, Redox reactions.

Module-II: Microbiology

- Fundamental Concept of Biology
- Stoichiometric Chemistry of micro-organisms
- Classification, Nomenclature, Morphology,
- Physiology and Growth Mechanisms of Microbes;
- Energetic and Interaction among biological population

- Influence of environmental factors on growth and distribution of microbes;
- Concept of Bio-technology as applied to the pollution control and waste degradation.

Recommended Books: (Latest editions where possible)

- Chemistry for Environmental Engineers by C. D. Sawyar, McGraw-Hill (latest edition).
- Environmental Chemistry by S. E. Manahan (2000) Lews Publisher London.
- Microbiology for Sanitary Engineering by R. E. Mc Kinmey McGraw-Hill (latest edition).
- Wastewater Microbiology by G. Britten (1994) Willy Inter-science New York.

Industrial Wastewater Pollution Control and Management 3(3-0)
Contents:

1. Introduction
- Management of Industrial Wastewater
- O&M Costs
- Management of Solid Wastes from Industries
- Management of Discharges to the Air

2. Fundamentals
- Characteristics of Industrial Wastewater
- Polar Solvents versus Nonpolar Solvents, True Solutions
- Emulsification
- Colloidal Suspensions

3. Laws and Regulations
- History of Permitting and Reporting
- Water Pollution Control Laws
- Groundwater Pollution Control Laws
- Air Pollution Control Laws

4. Type of Waste from Typical Industries
- Chemical Descaling
- Degreasing
- Rinsing
- Electroplating of Tin
- The textile industries
- The tanneries
- The Copper Forming Industry
- Prepared Frozen Foods
- Wastes From De-inking
- Die Casting: Aluminum, Zinc, and Magnesium
- Production and Processing of Coke
- The Synthetic Rubber Industry

- The Soft Drink Bottling Industry
- The Manufacture of Lead Acid Batteries

5. Industrial Storm Water Management

- Prevention of Groundwater Contamination
- Storm water Segregation
- Design Storm
- System Failure Protection
- Storm water Retention
- Storm water Treatment
- Storm water as a Source of Process Water Makeup

6. Waste Characterization

- Wastes Characterization Study
- Wastes Audit
- Environmental Audit
- Characteristics of Industrial Wastewater
- Characteristics of Discharges to the Air
- Sample Analysis
- Ambient Air Sampling
- Characteristics of Solid Waste Streams from Industries

7. Pollution Prevention Techniques

- Findings and Policy
- General Approach
- Source Reduction
- The Waste Audit
- Benefits of Pollution Prevention

8. Treatment and Disposal

- Principle and Non-principle Treatment Mechanisms for wastewater treatment
- Physical, chemical and biological treatment methods for industrial waste (liquid, solid and gases)

9. Case Studies

Recommended Books: (Latest editions where possible)

- Industrial Water Pollution Control by W. Wesley Eckenfelder, Jr. and
- INDUSTRIAL WASTEWATER MANAGEMENT, TREATMENT AND DISPOSAL, WEF, 2008
- Handbook of Industrial Pollution and Control by S. C. Bhatia
- Hazardous Waste Management by Michael D. LaGrega, Phillip L. Buckingham and Jeffery C. Evans
- Water Quality- Characteristics, Modeling and Modification by George Tchobanoglous and Edward D. Schroeder

Environmental Laws and Policies **3(3-0)**

Contents:

- An introduction to the law
  1. The Source of Environmental Law

2. The Litigation Process and Other Tools for Resolving Environmental Disputes
3. Administrative Law and Its Impact on the Environment

- The environmental laws
  1. An Introduction to Environmental Law and Policy
  2. Air-Quality Control
  3. Water-Quality Control
  4. Controlling Toxic Substances
  5. Waste Management and Hazardous Releases
  6. Energy
  7. Natural Resources
  8. International Environmental Law

Recommended Books: (Latest editions where possible)
Environmental Law, 8th Edition by GARY S. SILVERMAN

Watershed Management **3(3-0)**

- Hydrological Processes,
- Watershed and watershed management
- Types and distribution of precipitation,
- Glacier and ice caps-conservation strategy
- Limnology of wetland, lakes, estuaries, deltas and reservoirs
- Water losses and remedial measures
- Flood forecasting and flash floods
- Flow in stream, river, estuaries, wetlands, lakes and reservoirs.
- Ground water flow and water exploration techniques.
- Flood and drought management,
- Water conservation and rainwater harvesting,
- Water quality and water shed management,
- Water flow measurements & hydraulics;
- Sustainable development.

Recommended Books: (Latest editions where possible)

- Water Resource Engineering by Linsley McGraw-Hill.
- Hydrology and Flood plain analysis, by Philip B. Bedent (4th Edition)
- Hydrology and Management of Watersheds (3rd Edition) by Brooks

Anaerobic Wastewater Treatment **3(3+0)**

1. Basic Activated Sludge Process Theory
   a. Activated Sludge Configurations
   b. Conventional including tapered aeration, step feed, and other loading/aeration adaptations
   c. High rate including contact stabilization

d. Extended aeration including package plants
e. Fixed film + suspended growth hybrid systems (RBC, FAST, MBBR)

2. Biological Nutrient Removal (BNR)
   a. Nitrification & denitrification
   b. Anaerobic phosphorus removal
3. Anaerobic Membrane Bioreactors (AnMBR)
   a. General Design and Process Theory
   b. External separation systems
   c. Submerged (internal) systems
   d. BNR adaptations
4. Sludge Processing
   a. Sources and Characteristics of Sludge
   b. Grit and screenings
   c. Primary sludge
   d. Scum
   e. Secondary sludge
   f. Volume Reduction and Stabilization
   g. Aerobic digestion including auto thermal aerobic digestion
   h. Anaerobic digestion
5. Sludge Thickening Technologies
   a. Gravity thickeners
   b. Gravity belt thickeners
   c. Dewatering Technologies
   d. Centrifuges & decanters
   e. Horizontal belt filters
   f. Pressure filters
   g. Sand beds
   h. Sludge ("Biosolids") Disposal Techniques
6. Composting

Recommended Books

- Tong Zhang and Herbert H P Fang (2015) Anaerobic Biotechnology: Environmental Protection and Resource Recovery, Imperial College Press, ISBN-13: 978-1783267903
- Daniel J. Caruana (2011) Anaerobic Digestion: Processes, Products, and Applications, Nova Science Publishers, Inc., ISBN-13: 978-1613244203

Membrane Technology for Water and Wastewater Treatment **3(3-0)**

1. Membranes and Modules
   a. Isotropic and Anisotropic membranes

b. Metal, Ceramic, Zeolite, Carbon and Glass membranes
c. Hollow fiber membranes
d. Membrane modules
e. Module selection

2. Reverse Osmosis

a. Membranes and materials
b. RO membrane categories
c. Membrane selectivity
d. Membrane modules
e. Membrane fouling control
f. Applications

3. Ultrafiltration

a. Characterization of ultrafiltration membranes
b. Membrane fouling
c. Constant pressure modules, System design and Applications
d. Constant flux modules, System design and Applications

4. Microfiltration

a. Membrane characterization, modules, and process design
b. Applications

5. Desalination and Potable Water Purification

a. Forward Osmosis
b. Membrane Distillation
c. Energy Systems for RO
d. Ion-exchange membranes for water softening

6. Wastewater Treatment for Reclamation and Reuse

a. Water reuse by membrane technology
b. Membrane bioreactors
c. Brine treatment

Recommended Books:

- J. Mulder (1996) Basic Principles of Membrane Technology, 2nd Edition, Springer, ISBN-13: 978-0792342489
- Water Environment Federation (2011) Membrane Bioreactors, McGraw-Hill Education, ISBN-13: 978-0071753661
- Richard W. Baker (2012) Membrane Technology and Applications, 3rd Edition, Wiley, ISBN-13: 978-0470743720
- Rajindar Singh and Nicholas Hankins (2016) Emerging Membrane Technology for Sustainable Water Treatment, Elsevier, ISBN-13: 978-0444633125

ANNEXURE - A

English I (Functional English)

Objectives: 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

English II (Communication Skills)

Objectives: 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, minutes of meetings, use of library and internet

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-Christine 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 Richard York.

English III (Technical Writing and Presentation Skills)

Objectives: 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. McGraw-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 Northern Illinois University. General Editors: 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).

ANNEXURE - B

Pakistan Studies (Compulsory)

Introduction/Objectives

- Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.
- Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

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
      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

Recommended 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: An 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. Amin, Tahir. *Ethno - National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development.* Kent England: Wm Dawson & 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.

ANNEXURE - C

ISLAMIC STUDIES
(Compulsory)

Objectives

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.

Detail of Courses

Introduction to Quranic Studies

1. Basic Concepts of Quran
2. History of Quran
3. Uloom-ul-Quran

Study of Selected Text of Holly Quran

1. Verses of Surah Al-Baqara 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)

Study of Selected 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)

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

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

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

Selected Study from Text of Hadith

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

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

Islam & Science

1. Basic Concepts of Islam & Science
2. Contributions of Muslims in the Development of Science
3. Quran & Science

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

Political System of Islam

1. Basic Concepts of Islamic Political System
2. Islamic Concept of Sovereignty
3. Basic Institutions of Govt. in Islam

Islamic History

1. Period of Khlaft-E-Rashida
2. Period of Ummayyads

3. Period of Abbasids

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"
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 Jurisprudence 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)

ANNEXURE - D

Note: One course will be selected from the following six courses of Mathematics.

COMPULSORY MATHEMATICS COURSES FOR BS (4 YEAR) *(FOR STUDENTS NOT MAJORING IN MATHEMATICS)*

1. MATHEMATICS I (ALGEBRA)

Prerequisite(s): Mathematics at secondary level
Credit Hours: 3 + 0

Specific Objectives of the Course: To prepare the students, not majoring in mathematics, with the essential tools of algebra to apply the concepts and the techniques in their respective disciplines.

Course Outline:

Preliminaries: Real-number system, complex numbers, introduction to sets, set operations, functions, types of functions. *Matrices:* Introduction to matrices, types, matrix inverse, determinants, system of linear equations, Cramer's rule.

Quadratic Equations: Solution of quadratic equations, qualitative analysis of roots of a quadratic equations, equations reducible to quadratic equations, cube roots of unity, relation between roots and coefficients of quadratic equations.

Sequences and Series: Arithmetic progression, geometric progression, harmonic progression. *Binomial Theorem:* Introduction to mathematical induction, binomial theorem with rational and irrational indices. *Trigonometry:* Fundamentals of trigonometry, trigonometric identities.

Recommended Books

1. Dolciani MP, Wooton W, Beckenback EF, Sharron S, *Algebra 2 and Trigonometry*, 1978, Houghton & Mifflin, Boston (suggested text)
2. Kaufmann JE, College *Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston
3. Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6th edition), 1986, PWS-Kent Company, Boston

2. MATHEMATICS II (CALCULUS)

Prerequisite(s): Mathematics I (Algebra)
Credit Hours: 3 + 0

Specific Objectives of the Course: To prepare the students, not majoring in mathematics, with the essential tools of calculus to apply the concepts and the techniques in their respective disciplines.

Course Outline

Preliminaries: Real-number line, functions and their graphs, solution of equations involving absolute values, inequalities. *Limits and Continuity:* Limit of a function, left-hand and right-hand limits, continuity, continuous functions.

Derivatives and their Applications: Differentiable functions, differentiation of polynomial, rational and transcendental functions, derivatives.

Integration and Definite Integrals: Techniques of evaluating indefinite integrals, integration by substitution, integration by parts, change of variables in indefinite integrals.

Recommended Books

1. Anton H, Bevens I, Davis S, *Calculus: A New Horizon* (8th edition), 2005, John Wiley, New York
2. Stewart J, *Calculus* (3rd edition), 1995, Brooks/Cole (suggested text)
3. Swokowski EW, *Calculus and Analytic Geometry*, 1983, PWS-Kent Company, Boston
4. Thomas GB, Finney AR, *Calculus* (11th edition), 2005, Addison-Wesley, Reading, Ma, USA

3. MATHEMATICS III (GEOMETRY)

Prerequisite(s): Mathematics II (Calculus)
Credit Hours: 3 + 0

Specific Objectives of the Course: To prepare the students, not majoring in mathematics, with the essential tools of geometry to apply the concepts and the techniques in their respective disciplines.

Course Outline

Geometry in Two Dimensions: Cartesian-coördinate mesh, slope of a line, equation of a line, parallel and perpendicular lines, various forms of equation of a line, intersection of two lines, angle between two lines, distance between two points, distance between a point and a line.

Circle: Equation of a circle, circles determined by various conditions, intersection of lines and circles, locus of a point in various conditions.

Conic Sections: Parabola, ellipse, hyperbola, the general-second-degree equation

Recommended Books

1. Abraham S, Analytic Geometry, Scott, Freshman and Company, 1969

2. Kaufmann JE, College *Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston
3. Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6th edition), 1986, PWS-Kent Company, Boston

4. COURSE FOR NON-MATHEMATICS MAJORS IN SOCIAL SCIENCES

Title of subject:		MATHEMATICS
Discipline	:	BS (Social Sciences).
Pre-requisites	:	SSC (Metric) level Mathematics
Credit Hours	:	03 + 00
Minimum Contact Hours:		40
Assessment	:	written examination;
Effective	:	2008 and onward

Aims : To give the basic knowledge of Mathematics and prepare the students not majoring in mathematics.

Objectives : After completion of this course the student should be able to:

- Understand the use of the essential tools of basic mathematics;
- Apply the concepts and the techniques in their respective disciplines;
- Model the effects non-isothermal problems through different domains;

Contents :

1. *Algebra*

Preliminaries: Real and complex numbers, Introduction to sets, set operations, functions, types of functions. *Matrices:* Introduction to matrices, types of matrices, inverse of matrices, determinants, system of linear equations, Cramer's rule. *Quadratic equations:* Solution of quadratic equations, nature of roots of quadratic equations, equations reducible to quadratic equations. *Sequence and Series:* Arithmetic, geometric and harmonic progressions. *Permutation and combinations*: Introduction to permutation and combinations, *Binomial Theorem:* Introduction to binomial theorem. *Trigonometry:* Fundamentals of trigonometry, trigonometric identities. *Graphs:* Graph of straight line, circle and trigonometric functions.

2. *Statistics*

Introduction: Meaning and definition of statistics, relationship of statistics with social science, characteristics of statistics, limitations of statistics and main division of statistics. *Frequency distribution*: Organisation of data, array, ungrouped and grouped data, types of frequency series, individual, discrete and continuous series, tally sheet method, graphic presentation of the frequency distribution, bar frequency diagram histogram, frequency polygon, cumulative frequency curve. *Measures of central tendency*: Mean medium and modes, quartiles, deciles and percentiles. *Measures of dispersion*: Range, inter quartile deviation mean deviation, standard deviation, variance, moments, skewness and kurtosis.

Recommended Books

1. Swokowski. E. W., '*Fundamentals of Algebra and Trigonometry*', Latest Edition.
2. Kaufmann. J. E., '*College Algebra and Trigonometry*', PWS-Kent Company, Boston, Latest Edition.
3. Walpole, R. E., '*Introduction of Statistics*', Prentice Hall, Latest Edition.
4. Wilcox, R. R., '*Statistics for The Social Sciences'*,

5. MATHEMATICS FOR CHEMISTRY

Credit Hours: 3

Prerequisites: Mathematics at Secondary level

Specific Objectives of Course:

To prepare the students not majoring in mathematics with the essential tools of Calculus to apply the concepts and the techniques in their respective disciplines.

Course Outline

Preliminaries: Real Numbers and the Real Line, *Functions and their graphs*: Polynomial Functions, Rational Functions, Trigonometric Functions, and Transcendental Functions. Slope of a Line, Equation of a Line, Solution of equations involving absolute values, Inequalities. *Limits and Continuity:* Limit of a Function, Left Hand and Right Hand Limits, Continuity, Continuous Functions. *Derivatives and its Applications:* Differentiation of Polynomial, Rational and Transcendental Functions, Extreme Values of Functions. *Integration and Indefinite Integrals:* Integration by Substitution, Integration by Parts, Change of Variables in Indefinite Integrals. Least-Squares Line.

Recommended Books

1. Thomas, Calculus, 11th Edition. Addison Wesley publishing company, 2005.
2. H. Anton, I. Bevens, S. Davis, Calculus, 8th edition, John Willey & Sons, Inc. 2005.
3. Hughes-Hallett, Gleason, McCallum, et al, Calculus Single and Multivariable, 3rd Edition. John Wiley & Sons, Inc. 2002.
4. Frank A. Jr, Elliott Mendelsohn, Calculus, Schaum's Outline Series, 4th edition, 1999.
5. E. W. Swokowski, Calculus and Analytic Geometry PWS Publishers, Boston, 1983.
6. John H. Mathews, Numerical Methods for Mathematics Science and Engineering, Prentice-Hall, Second Edition 1992.

6. MATHEMATICS FOR PHYSICS

Contents

1. **Preliminary calculus.**

- Differentiation
  Differentiation from first principles; products; the chain rule; quotients; implicit differentiation; logarithmic differentiation; Leibnitz' theorem; special points of a function; theorems of differentiation.
- Integration
  Integration from first principles; the inverse of differentiation; integration by inspection; sinusoidal function; logarithmic integration; integration using partial fractions; substitution method; integration by parts; reduction formulae; infinite and improper integrals; plane polar coordinates; integral inequalities; applications of integration.

2. Complex numbers and hyperbolic functions

- The need for complex numbers
- Manipulation of complex numbers
  Additions and subtraction; modulus and argument; multiplication; complex conjugate; division
- Polar representation of complex numbers Multiplication and division in polar form
- de Moivre's theorem
  Trigonometrical identities; finding the nth roots of unity; solving polynomial equations
- Complex logarithms and complex powers

- Applications to differentiation and integration
- Hyperbolic functions
  Definitions; hyperbolic-trigonometric analogies; identities of hyperbolic functions; solving hyperbolic equations; inverses of hyperbolic functions; calculus of hyperbolic functions

3. Series and limits

- Series
- Summation of series
  Arithmetic series; geometric series; arithmetico-geometric series; the difference method; series involving natural numbers; transformation of series
- Convergence of infinite series
  Absolute and conditional convergence; convergence of a series containing only real positive terms; alternating series test
- Operations with series
- Power series
  Convergence of power series; operations with power series
- Taylor series
  Taylor's theorem; approximation errors in Taylor series; standard McLaurin series
- Evaluation of limits

4. Partial differentiation

- Definition of the partial derivative
- The total differential and total derivative
- Exact and inexact differentials
- Useful theorems of partial differentiation
- The chain rule
- Change of variables
- Taylor's theorem for many-variable functions
- Stationary values of many-variable functions
- Stationary values under constraints

5. Multiple integrals

- Double integrals
- Triple integrals
- Applications of multiple integrals
  Areas and volumes; masses, centers of mass and centroids; Pappus' theorems; moments of inertia; mean values of functions

- Change of variables in multiple integrals
  Change of variables in double integrals;

6. Vector algebra

- Scalars and vectors
- Addition and subtraction of vectors
- Multiplication by a scalar
- Basis vectors and components
- Magnitude of a vectors
- Multiplication of vectors
  Scalar product; vector product; scalar triple product; vector triple product
- Equations of lines and planes
  Equation of a line; equation of a plane
- Using vectors to find distances
  Point to line; point to plane; line to line; line to plane
- Reciprocal vectors

7. Matrices and vector spaces

- Vectors spaces Basic vectors; the inner product; some useful inequalities
- Matrices
- The complex and Hermitian conjugates of a matrix
- The determinant of a matrix
  Properties of determinants
- The inverse of a matrix
- The rank of a matrix
- Simultaneous linear equations
  N simultaneous linear equations in N unknowns
- Special square matrices
  Diagonal; symmetric and antisymmetric; orthogonal; Hermitian; unitary normal
- Eigen vectors and eigen values
  Of a normal matrix; of Hermitian and anti-Hermitian matrices; of a unitary matrix; of a general square matrix
- Determination of eigen values and eigen vectors Degenerate eigen values

8. Vector calculus

- Differentiation of vectors Composite vector expressions; differential of a vector

- Integration of vectors
- Space curves
- Vector functions of several arguments
- Surfaces
- Scalar and vector fields
- Vector operators
- Gradient of a scalar field; divergence of a vector field; curl of a vector field
- Vector operator formulae
- Vector operators acting on sums and products; combinations of grad, div and curl
- Cylindrical and spherical polar coordinates
- Cylindrical polar coordinates; spherical polar coordinates.

ANNEXURE - E

Statistics-I **Credit 3 (2-1)**

Definition and importance of Statistics in Agriculture, Data Different types of data and variables

Classification and Tabulation of data, Frequency distribution, stem-and-Leaf diagram, Graphical representation of data Histogram, frequency polygon, frequency curve.

Measure of Central tendency, Definition and calculation of Arithmetic mean, Geometric mean, Harmonic mean, Median quantiles and Mode in grouped and un-grouped data.

Measure of Dispersion, Definition and Calculation of Range, quartile deviation, Mean deviation, Standard deviation and variance, coefficient of variation.

Practical

a. Frequency Distribution
b. Stem-and-Leaf diagram
c. Various types of Graphs
d. Mean, Geometric mean Harmonic Mean,
e. Median, Quartiles Deviation, mean Deviation.
f. Standard Deviation, Variance, Coefficient of variation,
g. Skewness and kenosis

Recommended Books

1. Introduction to Statistical Theory Part- I by Sher Muhammad and Dr. Shahid Kamal (Latest Edition)
2. Statistical Methods and Data Analysis by Dr. Faquir Muhammad
3. A. Concise Course in A. Level Statistic with world examples by J. Crashaw and J. Chambers (1994)
4. Basic Statistics an Inferential Approach 2nd Ed. (1986) Fran II. Dietrich-II and Thomas J. Keans

Statistics-II **Credit 3 (2-1)**

Sampling Probability and non-Probability Sampling, Simple random sampling stratified random sampling Systematic sampling error, Sampling distribution of mean and difference between two means. Interference

Theory: Estimation and testing of hypothesis, Type—I and type-II error, Testing of hypothesis about mean and difference between two means using Z-test and t-test, Paired t-test, Test of association of attributes using X2 (chi-square) Testing hypothesis about variance.

Practical

a. Sampling random sampling
b. Stratified random sampling.
c. Sampling distribution of mean
d. Testing of hypotheses regarding population mean
e. Testing of hypotheses about the difference between population means
f. Chi-square test
g. Testing of Correlation Coefficient
h. Fitting of simple linear regression
i. One-way ANOVA
j. Two-way ANOVA

Recommended Books

1. Introduction to Statistical Theory Part-II by Sher Muhammad and Dr. Shahid Kamal (Latest Edition)
2. Statistical Methods and Data Analysis by Dr. Faquir Muhammad
3. Principles and Procedures of Statistics A Bio-material approach, 2nd Edition, 1980 by R. G. D Steal and James H. Tarric
4. Statistical Procedures for Agricultural Research 2nd Edition (1980) by K. A. Gomez and A. A. Gomez

ANNEXURE - F

Introduction to Information and Communication Technologies

Course Structure:	Lectures: 2 Labs: 1	**Credit Hours:** 3
Pre-requisite:	**None**	**Semester: 1**

Course Description

This is an introductory course on Information and Communication Technologies. Topics include ICT terminologies, hardware and software components, the internet and World Wide Web, and ICT based applications.

After completing this course, a student will be able to:

- Understand different terms associated with ICT
- Identify various components of a computer system
- Identify the various categories of software and their usage
- Define the basic terms associated with communications and networking
- Understand different terms associated with the Internet and World Wide Web.
- Use various web tools including Web Browsers, E-mail clients and search utilities.
- Use text processing, spreadsheets and presentation tools
- Understand the enabling/pervasive features of ICT

Course Contents

Basic Definitions & Concepts
Hardware: Computer Systems & Components
Storage Devices, Number Systems
Software: Operating Systems, Programming and Application Software
Introduction to Programming, Databases and Information Systems
Networks
Data Communication
The Internet, Browsers and Search Engines
The Internet: Email, Collaborative Computing and Social Networking
The Internet: E-Commerce
IT Security and other issues
Project Week
Review Week

Text Books/Reference Books

1. Introduction to Computers by Peter Norton, 6th International Edition, McGraw-Hill
2. Using Information Technology: A Practical Introduction to Computer & Communications by Williams Sawyer, 6th Edition, McGraw-Hill
3. Computers, Communications & information: A user's introduction by Sarah E. Hutchinson, Stacey C. Swayer
4. Fundamentals of Information Technology by Alexis Leon, Mathews Leon, Leon Press.