

CURRICULUM
OF
WATER MANAGEMENT
BS/BSc (Hons)/MS/MSc (Hons)
&
PhD

(Revised 2014)



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. It includes objectives & learning outcomes, course contents, scheme of studies, teaching methodologies and methods of assessment of learning. 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).

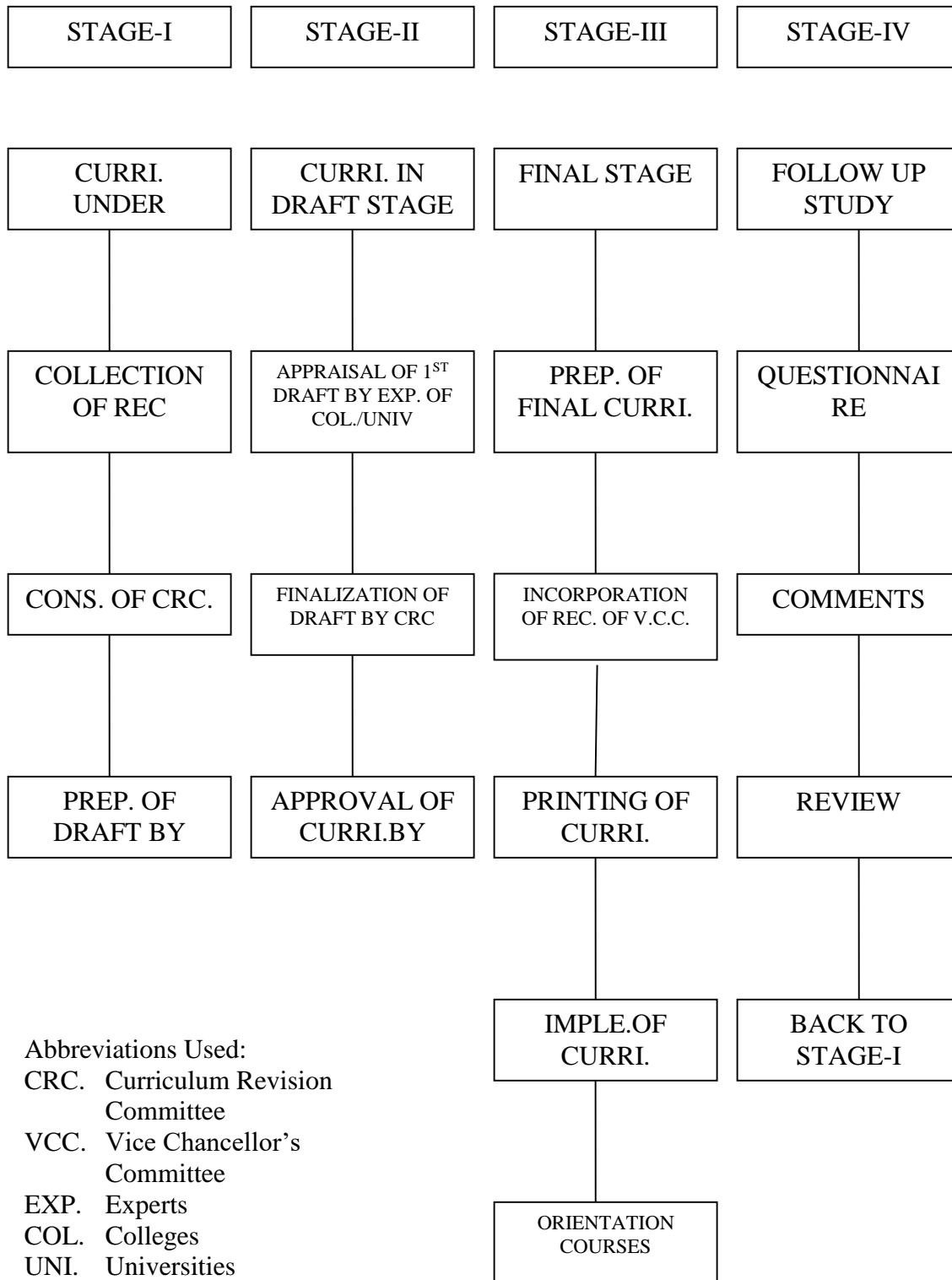
In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector 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 international standards, HEC NCRCs have developed unified templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering in 2007 and 2009.

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 (www.hec.gov.pk).

(Fida Hussain)
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

INTRODUCTION

The National Curriculum Revision Committee final meeting was held on April 7-9, 2014, at Higher Education Commission Regional Centre, Karachi, to finalize the draft curriculum in Water Management at graduate and postgraduate level developed in its preliminary meeting held on December 2-4, 2013, at Higher Education Commission Regional Centre, Lahore. The following experts attended the meetings:

1. Prof. Dr. Tahir Sarwar
Department of Water Management
The University of Agriculture
Peshawar
Convener
2. Prof. Dr. Abdul Razzaq Ghumman
Department of Civil Engineering
University of Engineering & Technology
Taxila
Member
3. Prof. Dr. Shahid Amjad
HOD, Dept. of Environment & Energy Management
Institute of Business Management
Karachi
Member
4. Prof. Dr. Tariq Masood Ali Khan
Institute of Environmental Studies
University of Karachi
Karachi
Member
5. Prof. Dr. Allah Bakhsh
Chairman
Faculty of Agricultural Engineering & Technology
Department of Irrigation & Drainage
University of Agriculture, Faisalabad
Member
6. Dr. Shahida Zakir
Associate Professor
Department of Environmental Sciences
University of Peshawar
Peshawar
Member
7. Dr. Sajid Mahmood
Assistant Professor
Centre of Excellence in Water Resources Engineering
University of Engineering & Technology, Lahore
Member

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|---|-----------|
| 8. Mr. Asif Javed Assistant Professor Department of Earth & Environmental Sciences Bahria University, Islamabad | Member |
| 9. Mr. Muhammad Irfan Malik Lecturer Water Resources Management Lasbela University of Agriculture Water & Marine Sciences, Uthal, Balochistan | Member |
| 10. Prof. Dr. Sajid Rashid Ahmad Institute of Geology, Quaid-e-Azam Campus University of the Punjab Lahore | Secretary |

Proceedings of the Preliminary Meeting (December 2-4, 2013):

Preliminary meeting of the National Curriculum Revision Committee (NCRC) in the discipline of Water Management was held on December 2-4, 2013 at HEC Regional Centre, Lahore. The meeting started with the recitation of verses from the Holy Quran by Mr. Abid Wahab (Assistant Director, HEC). Mr. Nazeer Hussain (Director, HEC Regional Center, Lahore) welcomed the participants and briefed about the role of HEC in strengthening the curriculum of water management and to bring it at par with international standards.

The committee unanimously agreed upon selecting Prof. Dr. Tahir Sarwar as Convener and Dr. Sajid Rashid Ahmad as Secretary of the NCRC in Water Management. Prof. Dr. Tahir Sarwar briefed the committee about the background of Water Management degree programme and its importance in agriculture. He also explained the previous revision of the curriculum in 2010 and asked the committee members to give their input for further improvement.

The committee thoroughly reviewed the curriculum according to agenda given by HEC.

On Day 1, the committee went through the scheme of study for 4-year BSc (Hons) Water Management programme at structural level and reviewed its courses and credit hours and found it satisfactory. Dr. Sajid requested all members to review the books and add new books in these courses. The committee members recommended several new books and latest edition to be incorporated in the curriculum.

On Day 2, the committee members thoroughly went through all courses from semester 5 to 8. They recommended several new topics and gave their input for addition of practicals and new books at BSc (Hons) level. The

committee realized that the contents of “Hydrometry” course have already been covered in other courses and replaced this course with new course namely “Hydromodeling”. Prof. Dr. Allah Bakhsh contributed significantly in preparing the contents of the said course. The committee rearranged the sequence of a few courses in the semesters. Prof. Dr. Khalid Naeem (Advisor, Academics HEC) also made a comprehensive presentation on uniformity in grading systems and emphasized the members to adopt preferred grading system (relative grading system) of HEC at their respective universities.

On Day 3, the members contributed their expertise for the revision of MSc (Hons) and PhD courses. They went through all the courses line by line and as a result some contents of courses were deleted and new were incorporated. The committee changed title of a few courses according to their contents. There was repetition in the contents of two courses (WM 704 and WM 714) therefore, the committee merged them into one course. Mr. Mushtaq Gill, (Ex-Director General, Water Management) gave his valuable input.

At the end of the meeting, Prof. Dr. Tahir Sarwar thanked the committee members for their valuable time and suggestions for the improvement of exiting curriculum of water management. He acknowledged the federal and regional administration of HEC for organizing the meeting in a befitting manner.

Proceedings of the Final Meeting (April 7-9, 2014):

NCRC final meeting for revision of Water Management curriculum was held on April 7-9, 2014, at LEJ, University of Karachi. Meeting started with the recitation from the Holy Quran by Prof. Dr. Abdul Razzaq Ghumman and was chaired by Mr. Ghulam Hyder Khan, Director, HEC, Regional Centre (RC), Karachi. He welcomed the participants and appreciated their efforts in preparing the draft during the preliminary meeting held on Dec 2-4, 2013, at HEC, RC, Lahore. He hoped that the members shall use the same zeal and efforts in finalizing the Water Management curriculum. He also offered his full cooperation to make the stay of participants comfortable at the University of Karachi. Due to late arrival of the Prof. Dr. Sajid Rashid Ahmad, Secretary, NCRC in Water Management, the committee requested Mr. Asif Javed to perform the duties of Secretary on April 7, 2014. The forum was then handed over to Prof. Dr. Tahir Sarwar, Convener of NCRC in Water Management. The Convener recalled that in the preliminary meeting more time was spent in revising the BSc. (Hons) programme in Water Management and very little time was left for MSc (Hons)/PhD programme. He suggested that in the final meeting the committee should make all possible efforts to finalize the BSc (Hons) programme in one day so that more time is available for the MSc (Hons)/PhD programme, which was unanimously agreed by the committee.

Initially, the BSc (Hons) programme was reviewed at the structural level. Some of the members showed serious reservations about the introduction of

Hydromodelling course at BSc (Hons) level and suggested that the same may be offered at MSc (Hons)/PhD level, which was unanimously approved by the committee. Then, the committee thoroughly reviewed courses of the BSc (Hons) programme one by one and made the necessary revisions in the contents. It was observed that the list of recommended books for each course was very long; therefore, it was decided to keep only the most relevant books for each course.

On second day (April 8, 2014), Prof. Dr. Sajid Rashid Ahmad took over the charge as Secretary of the NCRC meeting in Water Management. During the next two days (April 8-9, 2014), the committee thoroughly reviewed, discussed and updated the MSc (Hons)/PhD courses.

At the end of meeting, Mr. Ghulam Hyder Khan, Director, HEC, RC, Karachi and Mr. Abid Wahab, Assistant Director (Curriculum), HEC, Islamabad, thanked the committee members for their valuable time and suggestions.

The committee members highly acknowledged and appreciated the hospitality and cooperation of Mr. Ghulam Hyder Khan, Director, HEC, RC, Karachi, Mr. Mubashir Memon, Deputy Director, HEC, RC, Karachi, and Mr. Abid Wahab, Assistant Director (Curriculum), HEC, Islamabad during stay at Karachi.

Rationale

Water management can be defined as the planned development, distribution and use of water resources in accordance with predetermined objectives while respecting both the quantity and quality of the water resources. It is the specific control of all human interventions concerning surface and groundwater. Every planning activity relating to water can be considered as water management in the broadest sense of the term (ICID, 2000).

Many regions of the world are increasingly facing challenges when it comes to managing water. Although all challenges are related to water, the nature of the challenge differs from one location to the next. It may relate to having too little water while water demands are growing explosively (water scarcity), too much water (flooding), water of poor quality rendering them unfit to sustain the ecosystem or challenges related to providing water for people, industry and agriculture. What complicates matters further is that these challenges are all interdependent and influence each other. For example, water scarcity can impact water quality and the ability to provide water. Addressing these challenges requires that water managers apply an integrated and interdisciplinary approach, involving hydrological, biophysical, chemical, economic, institutional, legal, policy-making and planning aspects.

The programme focuses on scientific analysis of the physical, technical and socio-economic aspects of water management and on the ability to design sustainable and efficient technical solutions to water management problems.

Students in the programme develop comparative insight into the development of water management, take a scientific approach to various research paradigms and acquire a problem-oriented, interdisciplinary attitude towards land and water management and rural development issues. The programme addresses issues such as water resources management and the relationship between the hydrological cycle and agriculture. Management interventions for the conservation of soil and water and the maintenance of natural resources in sustainable farming are an integral part of water management degree programme. Socio-economic disciplines are integrated with technical aspects.

Goal/Aim:

Water Management degree programme provides the appropriate science and technology background required to manage water effectively and efficiently for agriculture. The common themes are the scientific assessment of plant water requirements and water resources, and the management of efficient irrigation systems.

On successful completion of the degree students will be able to:

- Implement and operate appropriate and sustainable solutions to irrigation and agricultural water management, with due regard to the technical, social and institutional constraints imposed by the surrounding environment;
- Assess crop water needs and plan for sustainable and efficient use of water resources;
- Have understanding of the physical water system and be able to predict and describe the impacts that human activities can have on the water and environmental resources
- Be able to explain principles, concepts and instruments of water resources and common and desired institutional and management arrangements
- Be able to model processes of water allocation and use at different scales, and interpret model outcomes in order to gain an understanding of problems, trends, causes and affects

Framework / Template for BS/BSc (Hons) in Agriculture with Specialization in Water Management

| | |
|----------------------------|---|
| Duration: | 4 years |
| Number of semesters: | 8 |
| Weeks per semester: | 16 - 18 (16 for teaching and 2 for exams) |
| Total credit hours: | 130-140 |
| Credit hours per semester: | 15-18 |
| Agriculture Courses: | 77% |
| Non-Agriculture Courses: | 23% |

| Non-Agriculture Domain | | | | | | | |
|--------------------------------|----------------------|---|-----------|---------------------------|---------------------------|-------------------|---------------------------|
| Knowle dge Area | Subject Area | Name of Course | CR | Total Cour ses | Total Cred Its | % Area | % ove rall |
| Humanities | English | English-I (Functional English) | 3 | 2 | 6 | 19.35 | 4.44 |
| | | English-II (Communication Skills) | 3 | | | | |
| | Culture | Pakistan Studies | 2 | 2 | 4 | 12.90 | 2.96 |
| | | Islamic Studies/ Ethics | 2 | | | | |
| | Social Sciences | Rural Development | 3 | 2 | 6 | 19.35 | 4.44 |
| | | Rural Sociology | 3 | | | | |
| Computing | IT | Intro to Information & Communication Technology | 3 | 1 | 3 | 9.70 | 2.22 |
| Natural Science | Mathematics/ Biology | Maths-I / Botany | 3 | 2 | 6 | 19.35 | 4.44 |
| | | Maths-II / Zoology | 3 | | | | |
| | Statistics | Statistics-I | 3 | 2 | 6 | 19.35 | 4.44 |
| | | Statistics-II | 3 | | | | |
| Sub-Total | | | 11 | 31 | 100 | 23 | |

| Agriculture Domain | | | | | | | |
|--|------------------------|-------------------------------------|---|-------|-------|------|------|
| Interdisciplinary | Agriculture Foundation | Basic Agriculture | 3 | 9 | 27 | 26.0 | 20.0 |
| | | Agronomy | 3 | | | | |
| | | Plant Breeding & Genetics | 3 | | | | |
| | | Entomology | 3 | | | | |
| | | Plant Pathology | 3 | | | | |
| | | Food Technology | 3 | | | | |
| | | Horticulture | 3 | | | | |
| | | Soil & Environmental Sciences | 3 | | | | |
| | | Agricultural Economics | 3 | | | | |
| Supporting/ Elective Courses (6-8 Courses) | Breadth Courses | Agriculture Extension | 3 | 4-6 | 12-18 | 15.0 | 11.0 |
| | | Plant Protection | 3 | | | | |
| | | Weed Science | 3 | | | | |
| | | Human Nutrition | 3 | | | | |
| | | Agriculture Chemistry | 3 | | | | |
| | | Engineering Applications to Agric. | 3 | | | | |
| | | Fundamentals of Water Management | 3 | | | | |
| | | Any other recommended by university | 3 | | | | |
| Major Courses (18-20 Courses) | Core (Depth) | Soil-Water-Plant Relations | 3 | 18-20 | 56-60 | 55.0 | 43.0 |
| | | Hydraulics | 3 | | | | |
| | | Surveying and Leveling | 3 | | | | |
| | | Hydrology | 3 | | | | |
| | | Indus Basin Water Management | 3 | | | | |
| | | Irrigation Water Quality | 3 | | | | |
| | | Water Wells and Pumps | 3 | | | | |
| | | Surface Irrigation Methods | 3 | | | | |
| | | GIS and Its Applications | 3 | | | | |
| | | Agrometeorology | 3 | | | | |
| | | Irrigation Scheduling | 3 | | | | |
| | | Participatory Water Management | 3 | | | | |
| | | Economics of Water Resources | 3 | | | | |
| | | Water Supply and Sanitation | 3 | | | | |
| | | Pressurized Irrigation | 3 | | | | |
| | | Agricultural Drainage | 3 | | | | |
| Irrigation Scheme Development | 3 | | | | | | |
| Watershed Management | 3 | | | | | | |

| | | | | | | | |
|----------------------|--|----------------------|---|-------|---------|-----|-----|
| Project / Internship | | Project / Internship | 4 | - | | 4 | 3 |
| Total | | | - | 31-35 | 99-109 | 100 | 77 |
| Grand-Total | | | - | 42-46 | 130-140 | - | 100 |

Curriculum for BSc (Hons) Agriculture with Specialization in Water Management

i. General Objectives of the Programme

BSc (Hons) programme in Water Management provides the basic science and technology background required to manage water effectively and efficiently for agriculture. The common themes are the scientific assessment of plant water requirements and water resources, and the management of efficient irrigation systems.

ii. Learning Outcomes of BSc (Hons) Programme

On successful completion of this programme students will be able to:

- Implement and operate appropriate and sustainable solutions to irrigation and agricultural water management, with due regard to the technical, social and institutional constraints imposed by the surrounding environment;
- Assess crop water needs and plan for sustainable and efficient use of water resources;
- Operate and manage pumps, conveyance and application systems; and
- Manage and schedule irrigation systems effectively and sustainably.

Scheme of Studies for BSc (Hons) Programme

| Course No. | Course Title | Credit Hrs |
|------------------------|--|------------|
| FIRST SEMESTER | | |
| Agr-301 | Basic Agriculture | 3(2-1) |
| Hort-301 | Introductory Horticulture | 3(2-1) |
| AgCh-301 | Introduction to Agricultural Chemistry | 3(2-1) |
| FST-301 | Introduction to Food Science & Technology | 3(2-1) |
| AEE-301 | Introduction to Agriculture Extension Education | 3(2-1) |
| WS-301 | Introduction to Botany or | 3(2-1) |
| Maths-301 | Math-I | 3(3-0) |
| Eng-301 | English-I | 3(3-0) |
| | Sub-total: | 21 |
| SECOND SEMESTER | | |
| PBG-311 | Introductory Genetics | 3(2-1) |
| RD-311 | Introduction to Rural Development | 3(3-0) |
| AgEc-311 | Introduction to Economics & Agricultural Economics | 3(3-0) |
| AgM-311 | Engineering Applications to Agriculture | 3(2-1) |
| ENT-311 | Zoology or | 3(2-1) |
| Math-311 | Math-II | 3(3-0) |
| CS/IT-311 | Introduction to Information and Communication Technologies | 3(2-1) |
| ISES-311 | Islamic Studies or Ethics (for Non-Muslims students) | 2(2-0) |
| | Sub-total: | 20 |
| THIRD SEMESTER | | |
| WS-401 | Introduction to Weed Science | 3(2-1) |
| PBG-401 | Introductory Plant Breeding | 3(2-1) |
| Ento-401 | Introductory Entomology | 3(2-1) |
| HN-401 | Introduction to Human Nutrition | 3(2-1) |
| Stat-401 | Statistics-I | 3(2-1) |
| RS-401 | Introduction to Rural Sociology | 3(3-0) |
| PakS-401 | Pakistan Studies | 2(2-0) |
| | Sub-total: | 20 |
| FOURTH SEMESTER | | |
| SES-411 | Introduction to Soil & Environmental Science | 3(2-1) |
| WM-001 | Fundamentals of Water Management | 3(2-1) |
| Eng-411 | English-II | 3(3-0) |
| Agr-411 | General Crop Production | 3(2-1) |

| | | |
|----------|---------------------------------|--------|
| PPL-411 | Introduction to Plant Pathology | 3(2-1) |
| Stat-411 | Statistics-II | 3(2-1) |
| PPR-411 | Introductory Plant Protection | 3(2-1) |
| | Sub-total: | 21 |

FIFTH SEMESTER

| | | |
|--------|------------------------------|---------|
| WM-002 | Soil-Water-Plant Relations | 3 (2-1) |
| WM-003 | Hydraulics | 3 (2-1) |
| WM-004 | Surveying and Leveling | 3 (2-1) |
| WM-005 | Hydrology | 3 (2-1) |
| WM-006 | Indus Basin Water Management | 3 (3-0) |
| | Sub-total: | 15 |

SIXTH SEMESTER

| | | |
|---------|----------------------------|---------|
| WM- 007 | Irrigation Water Quality | 3 (2-1) |
| WM- 008 | Water Wells and Pumps | 3 (2-1) |
| WM-009 | Surface Irrigation Methods | 3 (2-1) |
| WM-010 | GIS and Its Applications | 3 (2-1) |
| WM-011 | Agrometeorology | 3 (2-1) |
| | Sub-total: | 15 |

SEVENTH SEMESTER

| | | |
|--------|--------------------------------|---------|
| WM-012 | Irrigation Scheduling | 3 (2-1) |
| WM-013 | Participatory Water Management | 3 (3-0) |
| WM-014 | Economics of Water Resources | 3 (3-0) |
| WM-015 | Water Supply and Sanitation | 3 (2-1) |
| WM-016 | Pressurized Irrigation | 3 (2-1) |
| | Sub-total: | 15 |

EIGHTH SEMESTER

| | | |
|--------|-------------------------------|------------|
| WM-017 | Agricultural Drainage | 3 (2-1) |
| WM-018 | Irrigation Scheme Development | 3 (1-2) |
| WM-019 | Watershed Management | 3 (2-1) |
| WM-020 | Project/Internship | 4 (0-4) |
| | Sub-total: | 13 |
| | TOTAL | 140 |

DETAIL OF COURSES

FOURTH SEMESTER

WM-001 FUNDAMENTALS OF WATER MANAGEMENT 3(2-1)

OBJECTIVE:

To provide knowledge of the basic concepts of water management and its role in agriculture

THEORY:

Introduction: definition and scope of water management, its importance, goals and objectives, hydrologic cycle, sources of irrigation water, units of measurement. *Climate and Weather:* weather elements and their measurement, effect of weather elements on plant growth, agro-climatic zones of Pakistan. *Soil-Water-Plant Relations:* soil moisture, types of soil moisture, soil moisture constants, water requirements of crops, irrigation efficiencies. *Irrigation Scheduling:* importance of irrigation scheduling, determining when to irrigate, determining how much to irrigate. *Irrigation Systems:* components of irrigation system, Indus basin irrigation system, irrigation system management, water distribution schedules, spate irrigation. *Irrigation Methods:* surface irrigation; basin, border, furrow irrigation and pressurized irrigation; sprinkler and trickle irrigation; adoptability and limitations. *Groundwater:* aquifer, types of aquifer, properties of aquifers, groundwater movement, groundwater recharge. *Water Management in Rainfed Areas:* water management problems in rainfed areas, small-scale water harvesting, integrated watershed management

PRACTICAL:

Determination of soil moisture content, visit to a meteorological station, determination of saturation capacity, field capacity, wilting point and available water, visit to an irrigation scheme, flow measurement by different methods

RECOMMENDED BOOKS:

1. Ali, M. H. 2011. Practices of Irrigation & On-Farm Water Management: Volume 2. Springer, USA.
2. Choudhary, M. R. 2009. A Text Book of Irrigation and Drainage Practices for Agriculture. University of Agriculture, Faisalabad.
3. Kahlowan, M. A. and A. Majeed. 2004. Pakistan Water Resources Development and Management. Pakistan Council of Research in Water Resources, Ministry of Science and Technology, Government of Pakistan.
4. Micheal, A. M. 2003. Irrigation Theory and Practices. Vikas Publishing House (Pvt), New Delhi.
5. De bont, M. 1993. Water in Agriculture. Department of Water Management, The University of Agriculture, Peshawar.

FIFTH SEMESTER

WM-002

SOIL-WATER-PLANT RELATIONS

3 (2-1)

OBJECTIVE:

To provide an understanding of basic relationship of water to soil and plants and factors affecting crop water use

THEORY:

Introduction: importance, structure and properties of water, functions of water. *Soil-Water Relation:* soil properties like three phase system, texture and structure, concept of water potential, units of water potential soil, moisture-tension relationship, field capacity, wilting point, available water, measurement of soil moisture and potential, movement of water, infiltration, redistribution of infiltrated water and evaporation. *Plant-Water Relation:* plant processes, rooting characteristics, effective root depth, how do plants get water, movement of water in stem, leaf as controlling apparatus. *Atmosphere-Water Relation:* Atmosphere as source of energy, evapotranspiration (ET), factors influencing ET, measurement of ET. *Soil-Plant-Atmosphere System:* water uptake by root-systems from soil; water release by plant to atmosphere; effects of salts.

PRACTICAL:

Collection of disturbed/undisturbed soil samples, determination of water content by different methods, measuring soil moisture tension, determination of soil moisture retention curve/pF curve, plant root study

RECOMMENDED BOOKS:

1. Kirkham, M. B. 2005. Principles of Soil and Plant Water Relations. Elsevier Academic Press, Burlington.
2. Gupta, O. P. 2002. Water in Relation to Soils and Plant. Agrobios, Jodhpur.
3. Kramer, P. J., J. S. Boyer. 1995. Water Relations of Plant and Soils. Academic Press, London.
4. Sarwar, T. 2006. Lecture Notes: Soil-Water-Plant-Relations. Department of Water Management, The University of Agriculture, Peshawar, Pakistan.
5. Micheal, A. M. 2003. Irrigation Theory and Practices. Vikas Publishing House, New Delhi.

WM-003

HYDRAULICS

3 (2-1)

OBJECTIVE:

To provide understanding of hydraulics principles and their application to irrigation systems

THEORY:

Introduction: definition, fluid, pressure, mass, density, specific gravity, viscosity, surface tension and capillarity. *Fluid Statics:* pressure density-height relationship, absolute and gauge pressure. *Fundamentals of Fluid Flow:* concepts of water flow regime, continuity equation, energy equation, velocity head, kinetic energy, pressure energy, potential and elevation energy, application of Bernoulli's equation, energy grade line, hydraulic grade line. *Pipe Flow:* laminar flow, critical velocity, Reynold's number, Froude number, turbulent flow, velocity distribution, Darcy-Weisbach formula, friction factor. *Open Channel Flow:* difference between pipe flow and open channel flow, hydraulic parameters of open channel flow, channel cross section, Chezy's and Manning's equation, hydraulically most efficient cross-section.

PRACTICAL:

Dead weight pressure gauge calibrator, flow over weirs, Bernoulli's theorem demonstration, energy losses in pipes and bends, demonstration of series/parallel pumps.

RECOMMENDED BOOKS:

1. Kay, M. 2008. Practical Hydraulics. Taylor & Francis, Abingdon, UK.
2. Douglas, J. F. J. M. Gasiorek, J. A. Swaffield and Lynne B. Jack. 2005. Fluid Mechanics. Pearson Education Limited, Edinburgh, UK.
3. Khurmi, R.S. 2012. Textbook of Hydraulics and Fluid Mechanics. Chand & Co Ltd., India
4. Subramanya, K. 2008. Flow in Open Channels. Tata McGraw-Hill.
5. Akan, A. O. 2006. Open Channel Hydraulics. Butterworth-Heinemann, Burlington, MA, USA.

WM-004

SURVEYING AND LEVELING

3 (2-1)

OBJECTIVE:

To enable students to understand theory and practice of surveying and leveling and to develop skills to use modern survey instruments

THEORY:

Introduction to Surveying: definition; importance, types of survey. *Surveying Instruments:* chains, tapes, steel bands, their types and uses, GPS. *Compass Surveying:* prismatic compass and surveyor compass, uses, bearing, local attraction, fieldwork and plotting. *Plane Table Surveying:* parts and accessories, methods of plane table surveying and topographic mapping, contour map preparation and uses, contour lines, two point and three point problems. *Introduction to Leveling:* definition, benefits, general principles and methods of leveling, types and uses of levels, trigonometric leveling, leveling instruments/equipment, temporary and permanent adjustments of levels, computation of areas and volumes, precision land leveling, land grading, cut-fill ratio and earthwork calculations, measurement of area, cross-section,

elevations, contour lines, mass diagram, planimeter and its uses. *Modern Survey Instruments*: total station, theodolites, electronic distance measurement (EDM), GPS, temporary and permanent adjustments, measurement of horizontal and vertical distances and angles,

PRACTICAL:

Measurement of distances by different methods, compass surveying and traversing, level adjustments by two-peg method, profile and cross-sectioning, theodolite traversing, coordinates and area determination using GPS, contour mapping through Surfer software; total station

RECOMMENDED BOOKS:

1. Bhavikatti, S. S. 2008. Surveying and Levelling, Volume 1. I. K. International Pvt Ltd, India
2. Kanetkar, T.P. 2006. Surveying and Leveling (Part 1). Pune Vidyarthi Griha Prakashan, India.
3. Johnson, A. 2004. Plane and Geodetic Surveying. Spon Press, London.
4. Schofield, W., and M. Breach. 2007. Engineering Surveying. Butterworth-Heinemann Burlington, MA, USA.
5. Brinker, A.C. and Taylor, W.C. 2002. Elementary Surveying. International Textbook Co. Scranton, Pennsylvania.

WM-005

HYDROLOGY

3 (2-1)

OBJECTIVE:

To acquaint the students with principles and processes governing the movement of water through the hydrologic cycle, hydrograph, hydrologic statistics, and frequency analysis techniques

THEORY:

Introduction: hydrologic cycle and its components, climatic factors and their measurements, *Precipitation*: types and forms of precipitation and their measurement, runoff and its components, rainfall and runoff estimation, rainfall-runoff relations, factors affecting runoff, stream flow, interpretation of stream flow data, evaporation and transpiration, evapotranspiration and its estimation using different methods. *Hydrologic Analysis*: hydrograph and its characteristics, hydrographs for various durations, hydrograph separation, unit hydrograph development and application, unit hydrographs from complex storms, rainfall frequency and duration analysis, flood frequency and duration analysis. *Hydrologic Models*: definition, classification of models, development, calibration, verification and application of models. *Groundwater*: occurrence of groundwater, aquifers and classification, storage determination.

PRACTICAL:

Demonstration of weather recording instruments and practice in taking actual data from weather stations including a visit to weather station, measuring runoff

in the field by different techniques, development of unit hydrograph and its use, frequency analysis of rainfall data, measuring infiltration rate in the field

RECOMMENDED BOOKS:

1. Ghuman, A. R. 2013. Introduction to Hydrology. Department of Civil Engineering, the University of Engineering & Technology, Taxila, Pakistan.
2. Davie, T. 2008. Fundamentals of Hydrology. Routledge, Oxon, UK.
3. Raghunath, H.M. 2006. Hydrology Principles, Analysis and Design. New Age International Ltd.
4. Ward, R.C., Robinson, M. 1990. Principles of Hydrology. McGraw-Hill Book Co., London.
5. Awan, N.M. 1981. Surface Water Hydrology, National Book Foundation, Islamabad.

WM-006 INDUS BASIN WATER MANAGEMENT 3 (3-0)

OBJECTIVE:

To develop understanding about the water sources, functions, infrastructures and issues of IBIS. This module will provide an insight into existing basin management practices and suggestions for both improvements in existing practices and innovative options.

THEORY:

Introduction to Water Management Approaches: Water Resources Management (WRM), water management problems, Integrated Water Resources Management (IWRM), planning and management aspects, critics and challenges of IWRM. *Introduction to Indus Basin:* Indus basin-salient feature, overview surface water resources, groundwater resources, multiple use of water systems, water management challenges in the ibis. *Indus Water Treaty:* the context, Indus water treaty and apportioned rivers, Wular Barrage on river Jhelum, Kishenganga hydropower project, key policy issues. *Pakistan Water Apportionment Accord:* the context, disputes on water entitlements, water apportionment accord, key issues and challenges. *Climate, glaciology, and agro-ecosystems:* climate in the Indus basin, agro-climatic zones of Pakistan, snow and ice melt contribution to the total flow in the Indus basin, climate change impacts on the Indus basin. *Integrated Flood and Drought Management:* causes of floods, impacts of floods, causes and impacts of droughts, flood and drought management options in Pakistan. *Indus Basin Environmental Management:* flows below Kotri barrage, rivers to low flows below Kotri, minimum environmental flows (e-flows), issues of degradation of delta below Kotri, wastewater – industrial and domestic effluents. *Water Management Decision Support Systems:* need of optimization and different system levels, what is optimization? Optimization models and tools, decision support system models, example of DSS model.

RECOMMENDED BOOKS:

1. Pakistan University Water Network. 2014. Module A: Indus Basin Irrigation Management. <http://www.pakistanuniversitywaternet.org/lecture-notes>
2. Kahlowan, M. A. and A. Majeed. 2004. Pakistan Water Resources Development and Management. Pakistan Council of Research in Water Resources, Ministry of Science and Technology, Government of Pakistan.
3. Ahmad, N. 1993. Water Resources of Pakistan, Shahzad Nazir, 61 B/2, Gulberg, III, Lahore.

SIXTH SEMESTER

WM-007

IRRIGATION WATER QUALITY

3 (2-1)

OBJECTIVE:

To evaluate and identify potential problems related to irrigation water quality; to discuss possible restrictions of the use of water; and to present management options to cope with potential water quality related problems

THEORY:

Introduction: water quality and its importance; overview of major water quality problems; approaches to evaluate water quality, water quality criteria. *Salinity Problem:* introduction, build-up of soil salinity, salinity effects on crops, management of salinity problems; drainage, leaching, crop tolerance to salinity, cultural practices, changing methods of irrigation, land development, changing or blending water supplies. *Infiltration Problem:* infiltration problem and its evaluation, management of infiltration problem; soil and water amendments, blending water supplies, cultivation and deep tillage, organic residues, irrigation management. *Toxicity Problem:* specific ions and their effects; chloride, sodium, boron; management of toxicity problems; leaching, crop selection, cultural practices, blending water supplies; toxicity effects due to sprinkler irrigation. *Miscellaneous Problems:* excess nitrogen, abnormal pH, scale deposits, magnesium problems, trace elements and their toxicity; nutrition and water quality; clogging problems in drip irrigation system; vector problems

PRACTICAL:

Determination of electrical conductivity, sodium, calcium, magnesium, sodium adsorption ratio, carbonates, bicarbonates, chloride, and turbidity of irrigation water.

RECOMMENDED BOOKS:

1. Ayers, R. S. and D. W. Westcot. 1989. Water quality for agriculture. Food and Agriculture Organization of the United Nations (FAO), Rome
2. Duncan, R. R., R. N. Carrow, M. T. Huck. 2009. Turfgrass and Landscape Irrigation Water Quality: Assessment and Management. Taylor and Francis Group, USA.

3. Boyd, C. E. 2000. Water Quality: An Introduction. Springer.
4. Batram, J. 1996. Water Quality Monitoring. UNEP, Tokyo.
5. APHA. 2001. Standard Methods for Examination of Water and Wastewater. American Public Health Association, New York.

WM-008

WATER WELLS AND PUMPS

3 (2-1)

OBJECTIVE:

To familiarize the students with wells, pumps and their application in water management

THEORY:

Introduction: hydrological cycle, importance of wells, groundwater balance, conjunctive use of water, legal aspect of groundwater management. *Well Hydraulics:* aquifer, aquiclude, aquifuge and aquitard, unconfined aquifer, confined aquifers, perched aquifer, semi-confined aquifers, cone of depression, circle of influence, drawdown, Dupuit Thiem theory, steady state flow to aquifers. *Water Wells:* open/dug wells, tube wells, skimming and scavenger wells, strainer type tube wells, cavity type tube wells, slotted type tube wells, type of Strainers. *Construction of Open Wells:* wells with impervious lining, wells with pervious lining, *Kacha* wells, yield of an open well by constant level pumping test, yield of an open well by recuperation test. *Construction of Shallow and Deep Wells:* bored wells, driven wells, jetted wells, cable tool method, hydraulic rotary method, reverse rotary method. *Pumps:* components and classification, centrifugal, jet, positive displacement, turbine pumps, submersible pumps, propeller and mixed flow pumps and air lift pumps, types of impellers. *Terminology in Pumping Systems:* specific speed, priming, pumping energy, total dynamic head, pump problems and their remedies. *Power Requirement of Pump:* irrigation system head and power requirements, suction lift, well drawdown, friction head loss, operating head-seasonal-variation in system head curve, pump selection, prime mover electric, diesel and their selection, feasibility of prime mover selection

PRACTICAL:

Study of various components of well, measurement of well discharge; study of components and operational characteristics of various pumps, use of characteristic curves of different pumps, determination of pump efficiency,

RECOMMENDED BOOKS:

1. Michael, A. M., S.D. Khepar, and S.K. Sondhi. 2008. Water Wells and Pumps. McGraw-Hill
2. Misstear, B., D. Banks, and L. Clark. 2006. Water Wells and Boreholes. Wiley
3. Ahmad, N., 1995. Tube well Theory and Practices, Shahzad Nazir Publisher, Gulberg, III, Lahore.
4. Johnson. 1988. Ground Water and Wells. Minnesota, USA.

OBJECTIVE:

To provide an understanding of surface irrigation methods, irrigation delivery systems, schedules and evaluation of irrigation methods

THEORY:

Introduction: objective of irrigation, irrigation method and their selection, advantages and disadvantages of surface irrigation. *Surface Irrigation Methods:* uncontrolled flooding, basin, border, furrow, surge, and subsurface irrigation, irrigation efficiency and distribution uniformity, requirements for optimal performance. *Surface Irrigation Layout:* basic design process, computation of advance and intake opportunity time, flow rates, cut off time and field layouts. *Evaluation of Irrigation Methods:* application efficiency, deep percolation, advance, recession, flow geometry, infiltration, water storage efficiency, uniformity and reliability system evaluation. *Surface Irrigation Structures:* diversion structure, conveyance, distribution and management structures

PRACTICAL:

Study and demonstration of different surface irrigation methods, determination of irrigation efficiencies, evaluation of irrigation methods

RECOMMENDED BOOKS

1. Hoffman, G.J., R.G. Evans, M.E. Jensen, D.L. Martin, and R.L. Elliott. 2007. Design and Operation of Farm Irrigation Systems. 2nd Ed. ASABE, St. Joseph, MI, USA.
2. James, L. G. 1993. Principles of Farm Irrigation System Design. Krieger Publishing Company, Florida, USA
3. Michael, A.M. 2003. Irrigation, Theory and Practice. Vikas Publishing House, New Delhi, India.
4. Walker, W.R. and G. V. Skogerboe. 1987. Surface Irrigation: Theory and Practice. Prentice Hall, New Jersey.
5. Dilip, K.M. 2004. Irrigation Water Management Principles and Practices. Prentice Hall of India, New Delhi.

OBJECTIVE:

To equip the students with fundamental of GIS and its application in agriculture

THEORY:

Introduction: what is GIS, why GIS, history of GIS, functional components of GIS, questions GIS can answer, GIS data models: vector data model, raster

data model. *Spatial Data Acquisition and Management*: data acquisition techniques, data quality and assessment, accuracy, precision; map reference system, map projections, coordinate systems, properties of map projection, types of map projection, map datum. *GIS Database Management Systems*: what is database, advantages of database, components of DBMS. *Global Positioning System (GPS)*: brief history, components of GPS, how GPS work, GPS errors, absolute positioning, differential positioning, GPS applications. *Spatial Analysis*: what is spatial analysis, application areas, vector overlay analysis; buffering, map overlay, dissolve, clip, merge, select, eliminate, update, erase, and split tools; raster overlay analysis; high value vs low value, top map vs bottom map, factor combination model in raster GIS. *Remote Sensing*: why remote sensing, how remote sensing works, major component of remote sensing, remote sensing platforms and sensors, characteristics of optical sensors, earth resource remote sensing satellite, remotely sensed data characteristics: spectral, radiometric, spatial and temporal resolution, spectral signatures

PRACTICAL:

Hands on practices on ArcGIS software; displaying spatial data; classifying features and rasters; labeling features; georeferencing, use of GPS for acquiring data, extraction of catchment area, hillshad etc from digital elevation model (DEM)

RECOMMENDED BOOKS:

1. Chang, Kang-Tsung. 2006. Introduction to Geographic Information Systems. McGraw-Hill Higher Education, Columbus, Ohio, USA
2. Shamsi, U.M.. 2005. GIS Applications for Water, Wastewater, and Stormwater Systems CRC, Boca Raton, FL, USA
3. Bernhardsen, T., A. Viak and A. Norway. 2002. Geographic Information System: An Introduction. John Wiley & Sons Inc., New York, USA
4. Maidment, D. R. 2002. Arc Hydro: GIS for Water Resources. ESRI, Inc., USA.
5. ICIMOD. 2001. Application of GIS and RS in Planning for Mountain Agriculture and Land Use Management. International Centre for Integrated Mountain Development (ICIMOD), Nepal

WM-011

AGROMETEOROLOGY

3 (2-1)

OBJECTIVE:

To provide understanding of earth's climate and weather systems, processes and their role in agriculture

THEORY:

Introduction, scope, importance, composition of atmosphere, weather and climate, measurement of weather parameters; micro-meso-macro-phyto climates, electromagnetic spectrum, nature and properties of solar radiation,

transfer of heat, seasons, radiation and heat balance, vertical structure of atmosphere. Factors responsible for spatial and temporal variations in surface air temperature, diurnal and monthly variation of temperature, vegetation and air temperature; Atmospheric pressure and its variation with height, global distribution of pressure and wind, global circulation of atmosphere, atmospheric humidity, saturation and actual vapor pressure, relative humidity and dew point temperature, cloud formation and classification, types and forms of precipitation, rainfall over Pakistan, Monsoons, Agricultural seasons, weather and crops, crop weather relationships, climate types and vegetation, influence of altitude on crop distribution, influence of weather on crops. Weather forecasting in agriculture, weather and fertilizer application, weather service to farmers, crop weather diagrams and calendars, role of weather on insect pest and diseases, weather and climate related natural disasters, risk and management, climate change and global warming, weather modification.

PRACTICAL:

Visit of meteorological observatory, selection of site and layout of agro meteorological stations, procedures for installation of meteorological instruments, measurement of meteorological parameters, identification of clouds, automatic weather station and recording of weather data, processing and analysis of data, weather charts, preparation of crop weather calendars

RECOMMENDED BOOKS:

1. Stigter, K. 2009. Applied Agrometeorology. Springer Publishing Company, USA.
2. Prasad R., G. S. L. H. V. 2008. Agricultural Meteorology, Prentice-Hall of India Pvt. Ltd., New Delhi.
3. Harpal S., Ph.D. Mavi, Graeme J. Tupper. 2004. Agrometeorology: Principles and Applications of Climate Studies in Agriculture. CRC Press, Boca Raton, Florida, USA.
4. Varshneya, M. C. and Balakrishna Pillai, B. 2003. Textbook of Agricultural Meteorology. Indian Council of Agricultural Research, New Delhi.
5. Radha Krishna Murthy, V. 2002. Basic Principles of Agricultural Meteorology. BS Publications, Hyderabad, India.

SEVENTH SEMESTER

WM-012

IRRIGATION SCHEDULING

3 (2-1)

OBJECTIVE:

To provide the students a comprehensive introduction of the climate, crop, soil and environmental aspects determining the water balance of a cultivated field and the calculation of the crop water and irrigation water requirement

THEORY:

Introduction: importance of irrigation scheduling, determining when to irrigate, determining how much to irrigate. *Processing and Analysis of Weather Data:* methods on the processing and analysis of weather factors like temperature, precipitation, wind, sunshine, humidity and evaporation. *Determination of Potential Evapotranspiration:* estimation using aerodynamics, energy balance and empirical formulas. *Crop Water Requirement:* crop-coefficient, evapotranspiration, effective rainfall, readily available moisture (RAM), effect of RAM on reference evapo-transpiration. *Calculation of Irrigation Requirements:* calculating allowable depletion; Soil characteristics, root zones, available capacity and Management Allowed Deficit (MAD); calculating rate of depletion (net irrigation requirements), adjusting net irrigation requirements; salinity and leaching requirements, effective rainfall, ET during soil drainage, capillary movement from a water table. *Gross Water Requirements:* irrigation efficiency; uniformity, adequacy and timing, estimating efficiency; spray loss, percolation, runoff, leaching fractions; managing salinity, sodicity, specific ion effects; estimating gross irrigation requirements.

PRACTICAL:

Computation of reference crop evapotranspiration (ET_o), crop water requirement (ET_c), irrigation requirements, leaching requirements and irrigation scheduling, use of computer model (Cropwat) for determination of crop water requirement and irrigation scheduling

RECOMMENDED BOOKS:

1. Allen, R. G., L. S. Pereira, D Raes, and M. Smith. 1998. Crop Evapotranspiration - Guidelines for Computing Crop Water Requirements. FAO Irrigation and Drainage Paper 56. FAO, Rome, Italy
2. FAO. 1992. Crop Water Requirements. FAO Irrigation and Drainage Paper No. 24, Rome.
3. Bont de M. 1995. Lecture notes on Agrohydrology. Department of Water Management, NWFP Agricultural University, Peshawar.
4. Nielsen, D. R. 1990. Irrigation of Agricultural Crops. Agronomy No. 30. Publ. ASA, CSSA, SSSA.
5. Cuenca, R. H. 1989. Irrigation System Design - An Engineering Approach. Prentice Hall, Englewood Cliffs, NJ.

WM-013 PARTICIPATORY WATER MANAGEMENT

3 (3-0)

OBJECTIVE:

To provide students with basic concepts of the participation of all stakeholders in water management activities

THEORY:

Introduction, users' participation in development and management of irrigation, strategies for approaching farmers, integrated rural development, target groups in irrigation, practical methods to communicate with farmers, farmers

socio-economic context and irrigation development, the farming system, farmers' organizations, external relations of farmers for arranging inputs and outputs, the link of these aspects with irrigation design, construction and operation, Water Users' Associations, Water Users' Association Act, Water agreements/accords, local, regional and global, legislation about water and water vision of Pakistan, mass awareness, key water issues in Pakistan, electronic and print media, consultations, holding events, demonstrations of improved techniques and practices, case studies/ seminars

RECOMMENDED BOOKS:

1. Ahmad, Nisar. 2008. Participatory Irrigation Management. Higher Education Commission, Islamabad.
2. Khan, M. I., B. A. Tahir, S. Amir and N. Akhtar. 2004. Towards Participatory Management, Allama Iqbal Open University.
3. Shepherd, A. 1998. Sustainable Rural Development, St. Martin Press, Inc.
4. Burkey, S. 1993. People First: A Guide to Self-reliant Participatory Rural Development. Zed Books, London.
5. Nobe, K. C. and R.K. Samph. 1986. Irrigation Management in Developing Countries; Current Issues and Approaches, Studies in Water Policy and Management No. 8, West View Press, USA.

WM-014 ECONOMICS OF WATER RESOURCES 3 (3-0)

OBJECTIVE:

To provide the students with basic knowledge of principles of economics and their application in water management

THEORY:

Importance of economics in water management, cases and examples in which economics can play or have played a role, principles of water management economics, economic approaches to managing water, including quantity and price based policy instruments, institutional role, and benefit-cost analysis, money-time relationships, present and future worth of capital, cash flow diagrams, defining alternatives, alternative evaluations using B/C ratio, NPV & IRR, public Vs. private projects, economic models; economic valuation of water uses and decision-making context. Institutional economics, water law, how economics is used in policy and cost-benefit analysis, the roles of water marketing and water pricing, demand and supply estimation, privatization, and modeling with demand and supply functions. As part of the course, a role-play game will be conducted with course participants to help understanding of water resource management in the real world. Group work, presentation, and individual assignment will be part of learning process to improve understanding.

RECOMMENDED BOOKS:

1. Merrett, S. 2014. Introduction to the Economics of Water Resources: An International Perspective. Routledge, USA.
2. Griffin, R. C. 2006. Water Resource Economics: The Analysis of Scarcity, Policies, and Projects. Massachusetts Institute of Technology, USA.
3. Karamouz, M., F. Szidarovszky, and B. Zahraie. 2003. Water Resources System Analysis With Emphasis On Conflict Resolution. LEWIS Publisher.
4. Douglas, L, R. James, R. Lee. 1971. Economics of Water Resources Planning. McGraw Hill Book Company.

WM-015

WATER SUPPLY AND SANITATION

3 (2-1)

OBJECTIVE:

To provide the students with basic knowledge of water supply and sanitation

THEORY:

Introduction: overview of water supply and sanitation in Pakistan; health aspects of water supply and sanitation; water quality criteria. *Water Supply:* sources of water, choices of water sources (spring, wells etc) and their protection; forecasting population; consumption for various purposes, factors effecting consumption; economics of community water supply. *Water Treatment and Distribution:* sedimentation tank; coagulation; flocculation, usual coagulants, mixing devices, filtration, filter sand, classification of filters, disinfections, and chlorination. *Sanitation:* purpose of sanitation, site for sewage treatment work; water borne diseases and their control; health and water chemistry; planning and design of low cost sanitation.

PRACTICAL:

Determination of physical, chemical and biological characteristics of water, waste water and sewerage; determination of coagulation (Floc test) in water; visit to sewerage treatment plant.

RECOMMENDED BOOKS:

1. Hendricks D. 2011. Fundamentals of Water Treatment Unit Processes. CRC Press/ IWA Publishing
2. Hammer M.J. and M.J. Hammer. 2007. Water and Wastewater technology (6th edition). Prentice Hall, New Jersey.
3. Binnie C, M. Kimber M. and G. Smethurst. 2002 Thomas Basic water treatment. Telford Publishing
4. Viessman, W. and M. J. Hammer. 1998. Water Supply and Pollution Control. 6th Edition, Addison Wesley
5. Steel, W. Ernest. 1999. Water Supply and Sewerage. McGraw Hill Book Co. USA.

OBJECTIVE:

To equip the students with technical concepts and evaluation of pressurized irrigation systems.

THEORY:

Introduction: definition, scope, types, advantages and disadvantages.

Sprinkler Irrigation: components, types, layout of sprinkle irrigation system, sprinkle system evaluation, pressure requirements for set sprinkler systems.

Trickle Irrigation: components and methods, system layout, selection of emission devices, control of clogging, filtration, settling basin, media filter, screen filter, chemical treatment, and evaluation of trickle irrigation systems.

Low Head Pipelines: buried pipe distribution systems and selection for surface irrigation, system planning and design, design consideration for component structures, post-construction issues, cost analysis, upgrading and development.

PRACTICAL:

Design of sprinkle irrigation system, selection of sprinklers, and evaluation of sprinkler system; design of trickle irrigation system, selection of proper emitter and evaluation of drip irrigation system; design of low head pipeline; visit to a sprinkler and trickle irrigation project site

RECOMMENDED BOOKS:

1. Keller, J. 2001. Sprinkle and Trickle Irrigation. Blackburn Press, New Jersey, USA.
2. Phocaides, A. 2007. Handbook on Pressurized Irrigation Techniques. Food and Agriculture Organization of the United Nations, Rome.
3. Bliesner, R. D. and Keller, J. 2001. Sprinkle and Trickle Irrigation. Van Nostrand Reinhold.
4. Ahmed, S., M. Yasin, M. Aslam, A.G. Mangrio, M.M. Ahmed, R. Majeed, A. Rehan and T. Mustafa, 2001. A Handbook on Pressurized Irrigation Systems and Innovative Adaptations, WRII, NARC, Islamabad.

EIGHT SEMESTER**OBJECTIVE:**

To introduce the students with the concept of waterlogging, salinity and various drainage systems

THEORY:

Introduction: waterlogging and salinity, their causes and remedial measures, need for drainage; purpose of drainage; benefits of drainage; effect of poor

drainage on soil and plant; drainage problems in Pakistan; sources of excess water; relationship of irrigation and drainage. *Rainfall and its Relationship to Drainage*: mean rainfall over a basin or watershed; frequency of rainfall; characteristics of storm; time of concentration; the time of overland flow; different formulas for estimating runoff. *Flow of Water through Soil*: occurrence of ground water; saturated and unsaturated flow; flow of water through soil (Darcy's Law); measurement of hydraulic head; capillary flow above the water table; critical water table depth measurement of hydraulic conductivity; soil salinity control; leaching requirements. *Surface Drainage Systems*: surface drainage methods for flat lands and sloping lands, surface drain design; construction of surface drains, maintenance of surface drains. *Subsurface Drainage System*: types of subsurface drainage layouts, interceptor drain; relief drains; mole drains; material for subsurface drainage system; design process for subsurface drainage system; drainage coefficients; drain spacing formula; Hooghoudt's formula for steady state; determination of design depth and pipe diameter; layout and patterns; the pipe; and the envelope materials, outlets, installation, maintenance. *Vertical Drainage System*: factors affecting the feasibility of drainage wells; layout of drainage well systems; problems associated with vertical drainage; causes of failure of tubewell drainage in Pakistan, well configuration, design consideration, maintenance.

PRACTICAL:

Measurement of ground water table, processing and interpretation of groundwater data, determination of hydraulic conductivity, design/layout of surface, subsurface and tubewell drainage system, visit to drainage sites

RECOMMENDED: BOOKS:

1. Smedema, L. K. W. F. Vlotman, D. W. Rycroft. 2004. Modern Land Drainage: Planning, Design and Management of Agricultural Drainage Systems. Taylor & Francis
2. Micheal, A. M. and A. K. Bhattacharya. 2003. Land Drainage: Principles Methods and Application. Konark Publishers Pvt Ltd, India.
3. Siddiqui, I. H. 2003. Irrigation and Drainage Engineering. Royal Book Company, Karachi.
4. Ritzema, H. P. 1994. Drainage Principles and Applications. ILRI Publication 16. International Institute for Land Reclamation and Improvement, Wageningen, Netherlands.

WM-018 IRRIGATION SCHEME DEVELOPMENT 3 (1-2)

OBJECTIVE:

To focus on project planning and economic evaluation of irrigation schemes

THEORY:

Scheme Development Process: development of irrigation scheme on the basis of geophysical, technical and social criteria; the project cycle and strategies for

farmer's participation. *Scheme Design*: design of cropping pattern plans, pump selection and capacity calculation, layout and canal design. *Scheme Management*: calculation of the required irrigation intervals, rules for the operation and management of the scheme, economic evaluation of irrigation schemes (cost-benefit analysis of lining of canals, budget for the whole scheme), case studies

PRACTICAL:

Selection of a pump for the scheme, compute the capacity of the pump, analyze the involvement and participation of different stakeholders in the development process of the irrigation scheme, design a cropping pattern and compute the irrigation requirements of the scheme, layout of watercourses on the map of the scheme, longitudinal profile and design of watercourse for the scheme, preparation of the scheme budget, compute the irrigation intervals of different crops and design a water distribution plan, cost-benefit analysis of the scheme

RECOMMENDED BOOKS:

1. Agriculture New Zealand Ltd. 2001. Irrigation Scheme Development. MAF Information Bureau, Wallington.
2. FAO. 2001. Socio-economic Impact of Smallholder Irrigation Scheme Development in Zimbabwe: Case Study of Ten Irrigation Schemes. FAO, Rome.
3. Khan, M. Z. and M. de Bont. 1996. Project Studies Water Management. Lecture Notes. Department of Water Management, NWFP Agricultural University, Peshawar.

WM-019

WATERSHED MANAGEMENT

3 (2-1)

OBJECTIVE:

To provide an insight on the physical, chemical, biological, and ecological interactions within watershed

THEORY:

Introduction: importance and role of watershed management, issues and constraints in watershed management, socio-technical approaches for development, sustainable integrated watershed management, surveys in selected watersheds. *Appropriate Technology and Practices*: rehabilitation of degraded land, agroforestry systems and practices, bio-engineering practices for soil and water conservation, land slide control in upland watersheds, bio-technology of natural resource management, soil erosion, soil and water conservation. *Water Harvesting Practices*: micro-catchment development in local, regional and global, catchment area ratio and grid spacing, land development techniques, reducing runoff losses, agronomic practices, land surface modification, contour bunding, contour trenches, hillside conduit system, reducing evaporation losses (mulching), reducing losses from

reservoirs, forcing deep water penetration, reducing deep percolation losses, chemical treatment, anti-transparent; RS/GIS applications in watershed management

PRACTICAL:

Field trips to watersheds, case studies, determination of sediment load, evaluating biodiversity in watershed areas, delineation of watershed areas, land cover and soil loss using geospatial techniques

RECOMMENDED BOOKS:

1. Heathcote I. W. 2009. Integrated Watershed Management, John Wiley & Sons. Inc.
2. Beheim, E., G. S. Rajwar, M. Haigh, J. Krecek (Eds.). 2010. Integrated Watershed Management: Perspectives and Problems. Capital Publishing Company, Springer.
3. Gregersen, H., P. F. Folliott, and K. Brookes. 2008. Integrated Watershed Management: Connecting People to their Land and Water. Cabi Publishing.

WM-020

PROJECT/INTERNSHIP

(0-4)

All the universities/faculties/colleges may adopt project studies/internship programs according to their local environment/circumstances and may use their own procedure for evaluation. On completion of internship each student is required to write a formal report on his/her work and will present the report in seminar. The seminar / presentation delivered for internship will be mandatory but not be considered extra credit.

Curriculum for MS/MSc (Hons)/PhD in Water Management

i. General Objectives of the Programme

The MSc (Hons)/PhD programme focuses on the integrated management of hydrological features such as catchments, river basins and deltas. Integrated water management involves a process of participatory planning, decision making and implementation with the aim of achieving sustainable use of land and water resource systems. There is competition for water – regarding both its quantity and quality – between various uses and users. Water management has become a political issue that must be adapted to the needs of various stakeholders at all policy levels. In order to act within such a context, graduates must be capable of analyzing various forms of water use by various stakeholders; they must also be able to understand the strategies and viewpoints of decision makers and to assess alternative water management systems.

ii. Learning Outcomes of MSc (Hons)/PhD Programme

After completing this specialization, graduates will:

- Have understanding of the physical water system and be able to predict and describe the impacts that human activities can have on the water and environmental resources
- Be able to explain principles, concepts and instruments of water resources and common and desired institutional and management arrangements
- Be able to model processes of water allocation and use at different scales, and interpret model outcomes in order to gain an understanding of problems, trends, causes and effects
- Be able to describe socio-economic concepts that are relevant for water resources planning and management

Scheme of Studies

| Course No. | Course Title | Credit Hrs |
|------------|---|------------|
| WM-001 | Optimal Use of Irrigation Water | 3 (2-1) |
| WM-002 | High Efficiency Irrigation System | 3 (2-1) |
| WM-003 | Water Harvesting | 3 (2-1) |
| WM-004 | Water Resources Planning and Management | 3 (3-0) |
| WM-005 | Irrigation System Management | 3 (3-0) |
| WM-006 | Waterlogging and Salinity Management | 3 (2-1) |
| WM-007 | Environmental Impact Assessment | 3 (2-1) |
| WM-008 | Applied Hydrology | 3 (2-1) |
| WM-009 | Water Pollution Control | 3 (2-1) |
| WM-010 | Integrated Watershed Management | 3 (3-1) |
| WM-011 | Groundwater Management | 3 (2-1) |
| WM-012 | Reservoirs Operations and Management | 3 (2-1) |
| WM-013 | Remote Sensing and its Applications | 3 (2-1) |
| WM-014 | Hydro-Modelling | 3 (2-1) |
| WM-015 | Climate Change and Water Resources | 3 (3-0) |
| WM-016 | Wetland Conservation and Management | 3 (2-1) |
| WM-017 | Special Topics in Water Management | 3 (3-0) |
| WM-018 | Research Methodologies | 3 (3-0) |
| WM-019 | Special Problem (MSc) | 2 (0-2) |
| WM-020 | Seminar-I (MSc) | 1 (1-0) |
| WM-021 | Thesis (MSc) | 6 (0-6) |
| WM-022 | Special Problem (PhD) | 2 (0-2) |
| WM-023 | Seminar-II (PhD) | 1 (1-0) |
| WM-024 | Defense Seminar-III (PhD) | 1 (1-0) |
| WM-025 | Dissertation | 12 (0-12) |

Detail of Courses for MS/MSc (Hons)/PhD Programme in Water Management

WM-001 OPTIMAL USE OF IRRIGATION WATER 3 (2-1)

OBJECTIVE:

To equip the students with detailed knowledge of efficient use of water at farm level.

THEORY:

Introduction: crop water use, concept of relative yield and relative evapotranspiration, FAO method and its limitations, difference between seasonal ET deficit and ET deficit within a growth cycle. *Elementary*

Optimization Principles and Practices: choice of crop and variety, comparison of late vs. early varieties, adapting cropped area to water application (concept of full and deficit irrigation), distributing water deficit between crops in dependence of the sensitivity to seasonal and periodical water stress. *Varying Sowing Dates and Staggering:* shifting of crop water requirements and irrigation requirements in time and quantity, staggering sowing/planting; attenuating crop water requirements and irrigation requirements, effects of staggering. *Irrigation Scheduling:* irrigation scheduling and deficit irrigation; soil properties that can affect crop water requirements, different irrigation scheduling options (optimal vs. practical irrigation), adequacy of irrigation scheduling options, pre-irrigation, carry-over of soil moisture to the next crop, improving irrigation scheduling by water exchange. *Optimization of Cropping Pattern:* optimization the cropping pattern of an example farm in relation to land and water resources, optimization of cropping pattern taking in account farming goals, resources and constraints; effect of farmers goals (subsistence vs. generating cash income), resources (land, labour, water etc.) on the farm-level decisions, how to avoid or minimize risks.

PRACTICAL:

Use of Cropwat for determination of potential evapotranspiration, crop water requirements and irrigation requirements, exercises on different irrigation scheduling and scheme water supply options of Cropwat on the basis of climatological, soil and socio-economic data

RECOMMENDED BOOKS:

1. Hanson, B. 1999. Scheduling Irrigations: When and how much water to apply? University of California Irrigation Program, USA
2. Allen, R. G., L. S. Pereira, D Raes, and M. Smith. 1998. Crop Evapotranspiration - Guidelines for Computing Crop Water Requirements. FAO Irrigation and Drainage Paper 56. FAO, Rome, Italy
3. Dries, A. V. D. 1994. Lecture Notes: Optimal Use of Water. Department of Irrigation and Soil and Water Conservation, Wageningen Agricultural University, The Netherlands.
4. Rosher, K. 1991. Irrigation Delivery Scheduling. WAMA Project Paper No. WAMA/AUP-90/I1. NWFP Agricultural University, Peshawar.
5. Doorenbos, J., and A. H. Kassam. 1986. Yield Response to Water. Irrigation and Drainage Paper 33. FAO, Rome, Italy

WM-002 HIGH EFFICIENCY IRRIGATION SYSTEMS 3 (2-1)

OBJECTIVE:

To educate the students about different types of pressurized irrigation systems, their layout, design and evaluation

THEORY:

Selection of systems for orchards and row crops, irrigation efficiency of the system as compared to the existing irrigation system, various parameters used

for design of sprinkler/drip irrigation systems, use of sprinkler units, sprinkler guns, dripper and emitters in the system, layout and design of sprinkler and drip irrigation systems for the small and large farms, pre and post installation techniques for sustainability of the systems, fertigation. Buried pipe distribution systems for surface irrigation, distribution system selection, system planning and design, design consideration for component structures; post-construction Issues, cost analysis, upgrading and development, qualities of pipes used in the systems, Bill of quantity (BOQ), selection of pumps; design and construction of water tank; operation, maintenance and evaluation of the systems; application of computer software in the design and evaluation of high efficiency systems.

PRACTICAL:

Layout and design of sprinkler and drip irrigation systems, evaluation of the systems, field demonstration of sprinkler and drip irrigation systems, use of software Wetup, IRRICAD etc.

RECOMMENDED BOOKS:

1. Kessler and Sunset Books Staff. 2006. Sprinklers and Drip Systems. Oxmoor House, Inc., Des Moines, Iowa.
2. Keller, J. 2001. Sprinkle and Trickle Irrigation. Blackburn Press, New Jersey.
3. Ahmed, S., M. Yasin, M. Aslam, A. G. Mangrio, M.M. Ahmed, R. Majeed, A. Rehan and T. Mustafa, 2001. A Handbook on Pressurized Irrigation Systems and Innovative Adaptations, WRRRI, NARC, Islamabad
4. Bentum, Robert van and Ian K. Smout. 1994. Buried Pipelines for Surface Irrigation. The Water, Engineering and Development Center. Loughborough University of Technology, UK.

WM-003

WATER HARVESTING

3 (2-1)

OBJECTIVE:

To provide the students with detailed knowledge of various water harvesting techniques and their environmental and socio- economic considerations

THEORY:

Introduction: water harvesting, its importance, overview of the main types of water harvesting. *Rainfall-Runoff Analysis:* rainfall characteristics, variability of annual rainfall, probability analysis, rainfall-runoff relationship, determination of runoff coefficients; assessment of annual or seasonal runoff; runoff plots, design model for catchment area: cultivated area ratio. *Water Harvesting Techniques:* Micro-catchments techniques; contour bunds, eyebrow terrace, hill-slope micro-catchments, negarim, contour ridges etc., Macro-catchments techniques; hillside conduit, stone dams, liman terraces, cultivated reservoirs, farm ponds shallow wells. Flood Water Harvesting; floodwater harvesting

within the stream bed (Check dams); floodwater diversion (Sailaba, Rod Kohi etc.), storage; underground and above-ground storage. Spate irrigation, structures used in spate irrigation, roof-top water harvesting. *Socio-economic and Environmental Aspects*: socio-economic factors; people's demand, priorities and experiences, people's participation and gender issues, land tenure and water law issues, adaption and adoption, land suitability and area differences, environmental factors.

PRACTICAL:

Study of rainfall-runoff relationship, design of different water harvesting structures, field trips to various water harvesting sites

RECOMMENDED BOOKS:

1. Jana, B. L. 2008. Water Harvesting and Watershed Management. Agrotech Publishing Academy, Udaipur, India
2. Lancaster, B. 2006. Rainwater Harvesting for Dryland and Beyond. Volume 1, 2, and 3. Rainsource Press, Arizona
3. Govt. of Pakistan. 1996. Water Harvesting and Spate Irrigation. On-Farm Water Management Field Manual, Volume X. Federal Water Management Cell, Ministry of Food, Agriculture & Cooperatives, Govt. of Pakistan.
4. Critchley, W. and K. Siegert. 1991. Water Harvesting. Food and Agriculture Organization of United Nations (FAO), Rome.

WM-004

WATER RESOURCES PLANNING AND MANAGEMENT

3 (3-0)

OBJECTIVE:

To provide an understanding of surface and groundwater resources, planning and management issues, various treaties and economic accords in the management of water resources.

THEORY:

Present Status of Water Resources; water usage in agriculture, urban and rural sector, hydropower; water resources development potential; future challenges and options. *Surface Water resources Development and Utilization*: history of irrigation; Indus Water Treaty (1960); Water Apportionment Accord, trans-boundary issues. *Surface Water Resources Development and Utilization*: major rivers of Pakistan; average volume of water received; annual rainfall, seasonal inflow, water quality, sediments in rivers and reservoirs; harnessing of hill torrents; flood protection programme. *Groundwater Resources Development and Utilization*: necessity, aquifers, quality, recharge, extraction, development potential, mining, water table control, artificial recharge of groundwater. *Planning and Management Issues*: institutional objectives and constraints, management and sustainability issues - equity in water distribution, operation, management, cost recovery and water delivery

efficiencies; role of modeling, its advantages and limitations; environmental degradation; waterlogging and salinity, secondary salinization, salt balance in the Indus Plain, saline water intrusion, pollution of groundwater. *Economics of Water Resources*: economic approaches to the problems of resource use, pollution and sustainability, optimal use of renewable and non-renewable resources, externalities and public goods, valuation of environmental resources, simple examples illustrating how engineering and microeconomic analysis are used in water resources infrastructure planning and management; case studies dealing with water resources planning and management

RECOMMENDED BOOKS:

1. Griffin, R. C. 2006. *Water Resources Economics: The Analysis of Scarcity, Policies and Projects*. MIT Press, USA.
2. Loucks, D. P., E. van Beek, J. R. Stedinger, J. P. M. Dijkman, M. T. Villars, 2005. *Water Resources Systems Planning and Management: An Introduction to Methods, Models and Applications*. UNESCO, Paris.
3. Jain, S. and V. P. Singh. 2003. *Water Resources System Planning and Management*. Elsevier, Kidlington, UK
4. Dzurik, A. A. 2002. *Water Resources Planning*. Rowman & Littlefield Publishers, Inc., Lanham, MD
5. Ahmad, N. 1993. *Water Resources of Pakistan and Their Utilization*. Shahzad Nazir, 61-B/2, Gulberg-3, Lahore, Pakistan.

WM-005 IRRIGATION SYSTEM MANAGEMENT 3 (3-0)

OBJECTIVE:

To provide knowledge of flow control, water delivery policies, role of organizations, monitoring and evaluation of irrigation systems

THEORY:

Introduction: definition, importance of irrigation management, management cycle, activities in irrigation management. *Objective of Irrigation Management*: main interest groups, arranging objective by means and ends. *Water Delivery Policies*: acquisition water, water rights, cropping arrangement, water delivery arrangement. *Flow Control Systems*: characteristics of flow control, hydraulics of flow control, flow control concept, management objective and inputs. *Organization*: purpose and function, organizational structure, resource mobilization, farmers' participation, development of water users association. *Monitoring and Evaluation of Irrigation System Performance*: need, framework, purpose, requirements for monitoring, indicators and performance parameters, evaluation. Field visits, case studies

RECOMMENDED BOOKS:

1. Burton, M. A. 2010. *Irrigation Management: Principles and Practices*. Cabi Publications

2. Darra, B. L. and Raghuvanshi, C. S. 1999. Irrigation Management (Vol. 2). Atlantic, India.
3. Lorenzini, G. C.A. Brebbia. 2006. Sustainable Irrigation Management: Technologies and Polices. WIT Transactions on Ecology and Environment.
4. Joshi, L. K. and R. Hooja. 2000. Participatory Irrigation Management. Rawat Publications, India.

WM-006

WATERLOGGING AND SALINITY MANAGEMENT

3 (2-1)

OBJECTIVE:

To provide in-depth knowledge of waterlogging and salinity management

THEORY:

Introduction: sources and causes of waterlogging and salinity, the nature and extent of waterlogging and salinity problems in Pakistan, effect of waterlogging and salinity on crop yield, diagnosis of waterlogging and salinity and selection of control practices, salt tolerant crops, response to saline and sodic conditions; irrigation water quality assessments, leaching, leaching fraction, control of root zone salinity, crop production functions spatial and temporal variability in salinity. *Land Reclamation;* surface, subsurface, vertical, dry and bio drainage. *Treatment and Disposal of Drainage Water:* use of saline drainage water for irrigation, drainage water treatment and disposal options, institutional and local constraints, economic incentive and environments quality, conjunctive use of water. *Waterlogging and Salinity Management Options:* on farm irrigation and drainage practices, management of dry land saline seeps, project level waterlogging and salinity management options, biosaline agriculture

PRACTICAL:

Field sampling and monitoring of soil, water, plants, measurement techniques of waterlogging and salinity; use of dynamic optimisation models (e.g. Hydrus) in salinity and drainage management

RECOMMENDED BOOKS:

1. Hanson, B., S. Grattan and A. Fulton. 2003. Agricultural Salinity and Drainage. Publication #93-01. Department of Land, Air and Water Resources, University of California, Davis
2. Singh, R. V. 1992. Drainage and Salinity Control. Himanshu Publication, India.
3. Abrol, I. P., J. S. P. Yadv, F. I. Masood. 1988. Salt Affected Soils and their Management. FAO Bulletin 39, Rome, Italy.
4. Beltran, J. Martinez. 1978. Drainage and reclamation of salt-affected soils: Bardenas area, Spain. International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands.

5. FAO. 1973. Irrigation, Drainage and Salinity. Food and Agriculture Organization of the United Nations, Rome.

WM-007 ENVIRONMENTAL IMPACT ASSESSMENT 3 (2-1)

OBJECTIVES:

To understand principles, processes and techniques for assessment, mitigation and monitoring of projects.

THEORY:

Overview of environmental impact assessment, principles and purposes of IEE, EIA, SEA and its significance to the society; environmental impact indicators, baseline study; physical, biological and socioeconomic environment; main stages in EIA process, law, policy and institutional arrangements for EIA systems, selection of scientific and socio-economic factors in environmental impact assessment; identification of quantitative and qualitative environmental evaluation criteria; approaches for identifying, measuring, predicting, and mitigating environmental impacts Environmental management plan; environmental standards and EIA processes; public hearing steps and procedures; EIA methodologies for decision-making; guidelines for EIA, environmental evaluation of policies, EIA regulations of Pakistan

PRACTICAL:

Review and critically analyze an environmental impact statement document; case studies of water management projects; post construction evaluation and mitigation measures; participation in public hearing meetings

RECOMMENDED BOOKS:

1. Morris, P. and R. Therivel. 2009. Methods of Environmental Impact Assessment. Routledge, Oxon, UK.
2. Therivel R, J. Glasson and A. Chadwick. 2009 Introduction to Environmental Impact Assessment. Routledge, Taylor & Francis Group, Kentucky, USA.
3. Lawrence, D. P. 2005. Environmental Impact Assessment. John Wiley & Sons, Inc., Hoboken, New Jersey.
4. Awan, N. M. and M. Latif. 1999. Environmental Assessment of Irrigation and Drainage Projects. Volume 1 & 2.
5. Dougherty, T. C. and A. W. Hall. 1995. Environmental Impact Assessment of Irrigation and Drainage Projects. FAO Irrigation and Drainage Paper 53. FAO, Rome.

OBJECTIVE:

To equip the students with the application of hydrology in water management

THEORY:

Measurement, accuracy and evaluation of hydrological data; rainfall data analysis, discharge analysis. *Hydrograph*: concept, component and separation; factors affecting hydrograph shapes, time base of hydrograph, unit hydrograph, derivation of unit hydrograph using matrix solution, mathematical form of s-curve, complex hydrograph, synthetic hydrograph, Geographical Instantaneous Unit Hydrograph, hydrological methods for flood routing. applications of hydraulic techniques. *Hydrologic Statistics*: concepts, probability distribution, moments of distribution, co-variance, correlation and regression, frequency analysis, probability plots and goodness-of-fit tests, stochastic time series analysis, methods of time series analysis. Application of GIS/RS in hydrology

PRACTICAL:

Use of computer models in Hydrology such as GIUH, HEC GEOHMS, HEC GEORAS, HEC-RAS models.

RECOMMENDED BOOKS:

1. Dingman, S. L. 2008. Physical Hydrology. Waveland Press, Inc., Illinois.
2. Manning, J. C. 1996. Applied Principles of Hydrology. Prentice Hall, New Jersey.
3. Chow, Ven Te., D. R. Maidment, L. W. Mays. 1994. Applied hydrology. McGraw Hill, Columbus, USA.
4. Maidment, D. R. 1993. Handbook of Hydrology. McGraw-Hill, Columbus, USA.
5. Mutreja, K. N. 1992. Applied Hydrology. Tata McGraw-Hill Publishing Company Limited, New Delhi.

OBJECTIVES:

To teach about different sources of water pollution and their management techniques.

THEORY:

Introduction: Properties of water and its use, world water resources, water movement in the environment, water quality concerns, classes of agricultural pollutants, quantitative description of water quality, water quality as global issue. *Factors Affecting Water Quality*: temperature, precipitation, soil,

cropping practice, irrigation, characteristics of receiving water. *Pollutant Delivery Process*: adsorption characteristics, availability, detachment, transportation, pathways. Agriculture Pollutants: agriculture runoff as non-point pollution source, sediment pollution problems, plant nutrient, fertilizers, nitrogen fertilizers, phosphorus fertilizers, plant nutrient pollution problems, eutrophication; chemicals usage as pollution problem in agriculture, pesticides, herbicides, insecticides and fungicides, animal waste, salinity, biological water quality problems. *Water Pollution Control*: methods of controlling nutrients, sediments, animal waste, salts, and pesticides related pollution. *Water Quality Standards*: effluent, surface, stream, irrigation, US EPA, NEQS etc.

PRACTICAL:

Water, wastewater and sediments sampling, analyses of water quality for physical, chemical and biological parameters, field visit to water treatment plants.

RECOMMENDED BOOKS:

1. Dinar, A. and J. Albiac. 2009. The Management of Water Quality and Irrigation Technologies. Earthscan Publications Ltd.
2. Rao. S.V. 2007. An Introduction to Water Pollution. ICFAI University Press
3. Pearce, G.R. 1998. Agrochemical Pollution Risks Associated with Irrigation in Developing Countries: A Guide. Report OD- 141, HR Wallingford, United Kingdom.
4. Ongley, E.D. 1996. Control of Water Pollution from Agriculture. Food and Agriculture Organization of United Nation, Rome.
5. SCS. 1988. Water Quality Field Guide. Soil Conservation Service. United States Dept. of Agriculture, USA.

WM-010 INTEGRATED WATERSHED MANAGEMENT 3 (2-1)

OBJECTIVE:

Introduce students to watershed processes and functions and to the principles underpinning watershed management and decision-making; examine strategies for planning and management of watershed resources; provide exposure to watershed management issues and opportunity to formulate watershed management strategies and plans.

THEORY:

Watershed Assessment and Diagnosis: assessment of sustainability of current and potential land uses, diagnosis of problems and potentials, reforestation, land degradation assessment, environmental contamination, water quality and quantity. *Community-Based Participatory Analysis*: stake-holder identification, indigenous knowledge, conflicts and conflict resolution techniques (analytical hierarchy process); Identification of promising land uses. *Integration of Demographic and Socioeconomic Data*: demographic analysis, population carrying capacity, ecological footprints; economic criteria and social

acceptance. *Watershed Resource Allocation and Land-use Optimization*: resource allocation and land-use conversions. Multi-objective programming and generation of land-use planning scenarios: current and potential. Primary productivity and watershed resource degradation: assessment and monitoring. Biodiversity assessment, landscape fragmentation environmental impact assessment: approaches, techniques and applications; climate change adaptation and mitigation: watershed strategies

PRACTICAL:

Watershed boundaries and hydrologic network mapping, climatic inventory, generalized water balance calculation and mapping, climatic zoning, ecological zoning, landuse characterization and assessment, land use mapping, preparation of watershed management plan

RECOMMENDED BOOKS:

1. Gregersen, H. M., P. F. Ffolliott, and K. N. Brooks. 2007. *Integrated Watershed Management: Connecting People to their Land and Water*. CAB International, Oxfordshire, U.K. Google Books. ISBN 13:978-1-84593-281-7
2. Heathcote, I. W. 2009. *Integrated Watershed Management*. 2ND Edition. Wiley. ISBN 970-0- 470-37625-6.
3. Murty, J. V. S. 2004. *Watershed Management*. 2nd Edition. New Age International Publishers. New Delhi. Google Books. ISBN 81-224-0856-7.
4. Ritter, W.F. and A. Shirmohammadi (Eds). 2001. *Agricultural Nonpoint Source Pollution: Watershed Management and Hydrology*. CRC Press. ISBN 1-56670-222-4

WM-011

GROUNDWATER MANAGEMENT

3 (2-1)

Objective:

To equip the students with groundwater exploration techniques, well design, groundwater monitoring and blended, cyclic and treated use of groundwater

Theory:

Introduction to Groundwater: types of aquifer, Karez, groundwater resources of Pakistan, salt water intrusion, *Groundwater Exploration*: reconnaissance survey, surface investigation methods, subsurface investigations including test drilling, drilling methods, resistivity logging, radiation logging, temperature logging, velocity measurement and other methods. *Groundwater Management*: groundwater monitoring, observation network, water table fluctuation, selection of sites for the observation network, installation of observation wells and piezometers, conjunctive use of surface and groundwater, groundwater recharge, groundwater balance, groundwater quality

PRACTICAL:

Resistivity survey, interpretation of resistivity data, exercises for groundwater budgeting, groundwater mapping

RECOMMENDED BOOKS:

1. Kresic, N. 2008. Groundwater Resources: Sustainability, Management, and Restoration. McGraw-Hill, USA.
2. Raghunath, H. M. 2007. Groundwater. New Age International, India.
3. Mahajan, G. 1995. Ground Water Survey and Investigation. Ashish Publishing House, New Delhi, India.
4. Ahmad, N. 1995. Groundwater Resources of Pakistan. Shahzad Nazir, Lahore.
5. Karanth, K. R. 1987. Ground Water Assessment: Development and Management. Tata McGraw-Hill, India.

WM-012**RESERVOIR OPERATION AND
MANAGEMENT****3 (2-1)****OBJECTIVE:**

To acquaint the students with the understanding of reservoir operation and problems related to management of reservoirs.

THEORY:

Introduction, purpose of reservoir operation; reservoirs classification; storage, flood control, retarding, detention and distribution reservoirs. hydrological data required for reservoir operation, reservoir operation rules, policies and procedures; major reservoirs of Pakistan and their operational and management rules; regulation of flood control, power generation, irrigation. Single and multipurpose operation; determination of reservoir capacity required for specific yield or demand using mass curve; demand pattern for various type of reservoirs; sources of sediment, factors affecting erosion, silt load estimate for reservoirs; mechanism of sediment distribution in reservoirs; prediction of sediment distribution; estimation of life of a reservoir.

PRACTICAL:

Reservoir operation using simulation methods with help of historic and simulated inflows; computer models for reservoir operation and management; estimation of sediment load, life of reservoir.

RECOMMENDED BOOKS:

1. Tigrek, S., T. Aras. 2011. Reservoir Sediment Management. CRC Press, USA
2. Guggino, E., Rossi, Giuseppe, Hendricks, D. 1998. Reservoir Operation. Martinus Nijhoff Publishers, The Hague.

3. Cooke, G. D., E. B. Welch, S. Peterson, S. A. Nichols. 2005. Restoration and Management of Lakes and Reservoirs, Third Edition. CRC Press, USA
4. Votruba, L, and V. Broža. 1989. Water Management in Reservoirs.1989. Elsevier, UK.
5. Loucks, Stedinger and Haith. 1999. Water Resources System Planning and Analysis. Prentice Hall, New Jersey.

WM-013

REMOTE SENSING AND ITS APPLICATIONS

3 (2-1)

OBJECTIVE:

To acquaint the students with RS technologies and their applications in agriculture and water management

THEORY:

Introduction: what is remote sensing, electromagnetic radiation, electromagnetic spectrum, interactions with the atmosphere, radiation – target, passive vs. active sensing, characteristics of images, *Satellite Systems and Sensors:* on the ground, in the air, in space, satellite characteristics, spatial resolution, pixel size, and scale spectral resolution, radiometric resolution, temporal resolution, cameras and aerial photography, multispectral scanning, thermal imaging, geometric distortion, weather satellites, land observation satellites, marine observation satellites, other sensors, data reception, *Image Processing and Analysis:* visual interpretation, digital processing, preprocessing, image enhancement, image transformations, accuracy assessment, image classification and analysis, data integration and analysis, simple corrections, *Applications of Remote Sensing:* crop type mapping, crop monitoring and damage assessment, cropping pattern analysis, species identification, land use change analysis, hydrology, flood delineation, land cover, rural/urban change, desertification analysis, topo-mapping, oceans & coastal, water quality mapping and analysis, evaluation of the physical attributes of water resources

PRACTICAL:

Introduction to ERDAS Imagine, sub-set and mosaic, geo-registration, unsupervised classification, supervised classification , use of remote sensing for solving agricultural and water management problems

RECOMMENDED BOOKS:

1. CRC. 2014. Fundamental of Remote Sensing. Canada Centre for Remote Sensing. Natural Resources, Canada.
2. Jensen, J. R. 2007. Remote Sensing of the Environment: An Earth Resource Perspective. Prentice Hall, New Jersey, USA.
3. Jensen. J. R. 2004. Introductory Digital Image Processing. Prentice Hall, Inc., New Jersey, USA.

4. McCoy, R. M. 2004. Field Methods in Remote Sensing: Manual of Remote Sensing. Guilford Press.

WM-014

HYDRO-MODELLING

3 (2-1)

OBJECTIVE:

To provide the knowledge and skills of hydraulic measurements and its application in agriculture.

THEORY:

Introduction, types of models: physical, analog, analytical, mathematical, finite difference, finite elements, numerical, conceptual framework of model, model parameterization, initial conditions, boundary conditions, model calibration, model evaluation, model execution, validation and verification, sensitivity analysis, scenario simulation, theoretical overview of a typical hydro-model

PRACTICAL:

Data collection, preparation of input files, execution of model, model output controlling parameters, hands on experience of executing hydro model with different data sets in the form of group projects.

RECOMMENDED BOOKS:

1. Daoliang Li, Yingyi Chen. 2013. Computer and Computing Technologies in Agriculture. Part 1. Springer, USA.
2. Ralph A. Wurbs. 1994. Computer Models for Water-Resources Planning and Management: National Study. Texas A&M University, USA.
3. Maidment, D. R. 2002. ArcHydro: GIS for Water Resources, Volume 1. Environmental System Research Institute (ESRI), USA.
4. Peart, R. M., R. M. W. D. Shoup. 1998. Agricultural Systems Modeling and Simulation. Marcel Dekker Inc., USA.

WM-015

CLIMATE CHANGE AND WATER RESOURCES

3 (3-0)

OBJECTIVE:

To provide understanding of climate change, causes, effects, adaption, mitigation and its impact in water resources

THEORY:

Introduction: anthropogenic drivers of climate change, observed trends and impacts of climate change, projected trends and impacts of climate change, sources of scientific data. *Global Climate Change Policies:* climate change policy framework, provisions of the UNFCCC, Kyoto Protocol, main issues and negotiation streams, Post-2020 regime. *Climate Change Adaptation:*

conducting a vulnerability assessment, identifying and selecting adaptation options, linking adaptation and development planning, international Initiatives to support climate change adaptation. *Climate Change Mitigation*: Introduction, low carbon development, strategic frameworks and policy approaches for mitigation and low Carbon development, sectors with high mitigation potential, international initiatives to support climate change mitigation. *Climate Change Impact on Water Resources*: the role of hydrological cycle in the climate system, decade long precipitation variations and water resources, water availability and demand in south Asia, climate change and water resources, climate change and future water challenges, assessing impact of climate change on water resources on regional and smaller scales

RECOMMENDED BOOKS:

1. UNCC. 2014. Introductory e-course on Climate Change. United Nations Climate Change (UNCC) Learning Partnership. <http://unccelearn.org/>
2. Ahmad, Q. K. 2005. Climate Change and Water Resources in South Asia. CRC Press, Boca Raton, Florida, USA.
3. Aguado, E. Burt, J. 2006. Understanding Weather and Climate. Prentice Hall, London.
4. Garbrecht, J. and T. Piechota. 2005. Climate Variations, Climate Change, and Water Resources Engineering. American Society of Civil Engineers, USA.
5. Kininmonth, W. 2004. Climate Change: A Natural Hazard, Multi-Science Publishing Co. Ltd.

WM-016

WETLAND CONSERVATION AND MANAGEMENT

3 (2-1)

OBJECTIVE:

To understand the natural and manmade processes of wetland environments, impacts and management

THEORY:

History of wetland science and management; significance, concept, types, functions, values and classification, elements of wetlands management; managerial issues, stakeholders participation and case studies in wetlands of Pakistan; wetlands identification, delineation, wetlands assessment and monitoring; ecological survey design and sampling techniques; wetlands and water quality; natural wetland protection and riparian areas as buffers; management of exempt wetland activities, restoration, creation and constructed wetlands; ecosystem, biodiversity, ecology, ecology of streams and rivers, lake ecology; fishpond management and fish parasites; wetland and floodplain ecology, structure, functioning and special characteristics of tropical river and lake ecosystems; investigating activities/ processes in the watershed and its effects on freshwater ecosystems and relevant ecosystem services

PRACTICAL:

Building a wetland filter; water sampling at key wetlands sites; field visits for ecological, mammal, plant, reptile, wildlife identification at key wetlands sites, insect and socio-economic, variations in different species at wetlands; evaluation and hydrological survey; designing a management plan for wetland conservation

RECOMMENDED BOOKS:

1. Mitsch, W. J. and James G. Gosselink. 2007. Wetlands. John Wiley & Sons, Inc., Hoboken, New Jersey.
2. Batzer, D. P. and R. Sharitz. 2007. Ecology of Freshwater and Estuarine Wetlands. University of California Press.
3. Keddy, P. A. 2002. Wetland Ecology: Principles and Conservation. Cambridge University Press, UK.
4. Haslam, S. M. 2000. Understanding Wetlands: Fen, Bog and Marsh. Cambridge University Press, UK.
5. Tiner, R. W. 1999. Wetland Indicators: A Guide to Wetland Identification, Delineation, Classification and Mapping. CRC Press, Boca Raton, Florida.
6. Moshiri, Gerald A. 1993. Constructed Wetlands for Water Quality Improvement. Wetland Sciences Incorporated, Florida, USA.

WM-017**SPECIAL TOPICS IN WATER
MANAGEMENT****3 (3-0)****OBJECTIVE:**

To provide the students the knowledge and understanding on topics of temporal or special interest in water management

THEORY:

They cover topics of temporal or special interest in water management which will not be made a regular on-going part of the curriculum. Experimental courses may also be offered as special topic courses and subsequently proposed as a regular course. Special topics must meet the same standard as academic credit course in every way.

RECOMMENDED BOOKS:

There is no specific book recommended for this course. Books, reports, journal and other research publications related to the topics selected for the course will be utilized.

OBJECTIVES:

To understand some basic concepts of research and its methodologies; identify appropriate research topics; select and define appropriate research problem and parameters

COURSE OUTLINE:

Purpose of research; research project conceptualization, choice of methods; elements of a research proposal, operationalization choices and illustrations. *Research Design*: formulation of research design, pretesting of research instruments and procedures, units of analysis, time dimension; experimental design and use of indicators in research; *Survey Research*: guidelines for asking question and questionnaires construction, self-administered questionnaires, interview and other survey methods; their strength and weaknesses. *Sampling*: the logic of sampling, concepts and terminologies, population and sampling frames, types of sampling design. *Field Studies*: Steps in the conducting field study; *Evaluation Research*: How to carry out evaluation research; analytical tools in research: qualitative and quantitative methods; *Statistical Analyses*: univariate, bivariate and multivariate analyses.

RECOMMENDED BOOKS:

1. Sahu, P. K. 2013. Research Methodology: A Guide for Researchers In Agricultural Science, Social Science and Other Related Fields. Springer, USA.
2. Kothari, C. R. 2004. Research Methodology: Methods and Techniques. New Age International, India.
3. Leedy, P. D. and Ormond, J. E. 2010. Practical Research: Planning and Design. Upper Saddle River, New Jersey, USA.
4. Creswell, J. W. & Plano Clark, V.L. 2007. Designing and Conducting Mixed Methods Research. Thousand Oaks, Sage CA, USA

Individual students are required to select a water management problem on which they conduct a small investigation during this course. In several steps the students will be guided through all the phases of a research cycle; writing a research proposal, implementation of the research, analysis of data, writing a report and finally they have to present their research in a seminar. In this way the students learn how to conduct research and this will be useful for their MSc/PhD research. This will provide them the opportunity to approach problems in a systematic way; and whether the students become researchers, planners or managers, they will always be required to approach and solve problems.

During the course the students will be trained in:

- writing a research proposal on a small water management problem;
- looking for literature in the library in a systematic way;
- writing a scientific report;
- presenting the research design, the results and conclusions in a seminar.

RECOMMENDED BOOK:

Leedy, P. D. and Ormond, J. E. 2010. Practical Research: Planning and Design. Upper Saddle River, New Jersey, USA.

WM-020/WM-023

SEMINAR

1(1-0)

This course is meant to give students practice speaking in front of audience and to explore topics of their own choosing in detail. Students will research topics and organize presentations for faculty and other students. The topics may be any aspect of water management and must be approved by the instructor in advance. To help students improve as speakers, each student will receive feedback from the fellow students and the instructor.

Detail of Compulsory Courses

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 Françoise 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. Brian 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).

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.

**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)

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

| | |
|-----------------------------------|--------------------------------|
| <i>Title of subject</i> : | MATHEMATICS |
| <i>Discipline</i> : | BS (Social Sciences). |
| <i>Pre-requisites</i> : | SSC (Metric) level Mathematics |
| <i>Credit Hours</i> : | 03 + 00 |
| <i>Minimum Contact Hours</i> : 40 | |
| <i>Assessment</i> : | written examination; |
| <i>Effective</i> : | 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, median 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.

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

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.

Functional Biology-I Credit Hours 3+0

Biological Methods

Principles of Cellular Life

Chemical Basis

Structure and Function

Principles of Metabolism

Energy Acquisition

Principles of Inheritance

Mitosis and Meiosis

Chromosomes

Observable Inheritance Patterns

DNA Structure and Function

RNA and Proteins

Genes

Genetic Engineering and Biotechnology

Biodiversity

Fundamental Concept of Biodiversity

One or two examples of each of the following from commonly found organism

Prions

Viruses

Bacteria

Protistans

Algae

Fungi

Plants

Crops

Animals

Invertebrates

Vertebrates

Reading:

1. Roberts, M.M., Reiss and G. Monger. 2000. Advanced Biology, Nelson.
2. Starr, C, and R, Taggart, 2001. Biology: The Unity and Diversity of Life Brooks and Cole.
3. Campbell, N.A., J.B, Reece, L.G. Mitchell, M.R, Taylor. 2001. Biology: Concepts and Connections. Prentice-Hall.

Functional Biology-II Credit Hours 3+0

Myths and Realities of Evolution

Microevolution

Speciation

Macroevolution

Level of Organization

Plants

Tissues

Nutrition and Transport

Reproduction

Growth and Development

Animals

Tissue, Organ System and Homeostasis

Information Flow and Neuron

Nervous System

Circulation and Immunity

Nutrition and Respiration

Reproduction and Development

Ecology and Behavior

Ecosystems

Biosphere

Social Interactions

Community Interactions

Human Impact on Biosphere

Environment Conservation

Reading:

1. Roberts, M.M., Reiss and G.Monger. 2000. Advanced Biology, Nelson.
2. Starr, C, and R, Taggart, 2001. Biology: The Unity and Diversity of Life Brooks and Cole.
3. Campbell, N.A., J.B, Reece, L.G. Mitchell, M.R, Taylor. 2001. Biology: Concepts and Connections. Prentice-Hall.

Note:

Universities may make necessary changes in the courses according to the requirement as decided by the Board of Studies.

General Recommendations:

The committee appreciated the role of HEC in improving higher education in the country. The participants of the National Curriculum Revision Committee of Water Management formulated the following recommendations.

1. A committee may be constituted to monitor the implementation process of the curriculum.
2. HEC may arrange national/ provincial workshops to share the contents of water management program with all stakeholders.
3. HEC/Universities may arrange training of faculty members on the newly developed courses on priority basis.
4. Short refresher courses/workshops pertaining to teaching methods and information technology may be arranged for improvement of teaching skills.
5. Books (text, reference, digital), software (water related) and satellite data should be provided to students by HEC or Universities.
6. HEC may arrange training of the in-service junior faculty members through using the capabilities and expertise of the senior faculty in the areas where universities feel deficiency.
7. Periodic inter-university/inter-provinces visits of faculty members may be arranged to exchange the views and observe the site specific technological development in different provinces/universities.

