

**REVISED CURRICULUM
OF
WATER MANAGEMENT**

Curriculum Development Project
Sponsored by
Ministry of Science & Technology
Islamabad



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CURRICULUM DIVISION, HEC

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*Composed by **Mr. Zulfiqar Ali**, HEC, Head Office, Islamabad*

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PREFACE

Curriculum of a subject is said to be the throbbing pulse of a nation. By looking at the curriculum of a subject, one can judge the state of intellectual development and the state of progress of a nation. The world has turned into a global village, new ideas and information are pouring in a constant stream. It is, therefore, imperative to update our curricula by introducing the recent developments in the relevant fields of knowledge.

In exercise of the powers conferred by Sub-section (1) of section 3 of the Federal Supervision of Curricula Textbooks and Maintenance of Standards of Education Act 1976, the Federal Government vide Notification No.D773/76-JEA (Cur.), dated December 4, 1976, appointed Higher Education Commission as the Competent Authority to look after the Curriculum Revision Work beyond Class XII at Bachelor level and onwards to all Degrees, Certificates and Diplomas awarded by Degree Colleges, Universities and other Institutions of higher education.

In pursuance of the above decisions and directives, the Commission is continually performing curriculum revision in collaboration with the Universities. According to the decision of the 44th Vice-Chancellors' Committee, curriculum of a subject must be reviewed after every 3 years. For the purpose, various Committees are constituted at the national level comprising senior teachers nominated by the Universities. Teachers from local degree colleges and experts from user organizations, where required, are also included in these Committees.

The National Curriculum Revision Committee on **Water Management** in its meeting held in July 2003 at the H.E.C. Regional Centre, Karachi finalized the draft curriculum after due consideration of the comments and suggestions received from the Universities and Colleges where the subject under consideration is taught.

The Final draft prepared by the Curriculum Revision Committee duly approved by competent authority is being circulated for implementation by the Universities.

(PROF. DR. ALTAF ALI G. SHAIKH)
D.G. (CURRICULUM)

November 2003

INTRODUCTION

A meeting of National Curriculum Revision Committee to finalize the draft curriculum of Water Management and its recommendations for effective implementation of revised draft was held on April 22-24th, 2003 at HEC, Regional Centre, Lahore. Earlier, a revised draft curriculum was prepared in its preliminary meeting held in January 2003. The following attended:

1. Prof. Dr. Muhammad Latif, Convener
Director,
Centre of Excellence in Water Resources Engineering,
University of Engg. & Technology,
Lahore
2. Prof. Dr. Nisar A. Memon Member
Department of Irrigation and Drainage,
Sindh Agriculture University,
Tandojam.
3. Prof. Dr. Muhammad Rafiq Choudhry Member
Department of Irrigation and Drainage
University of Agriculture,
Faisalabad.
4. Dr. Anwar Nasim, Member
Adviser Science,
COMSTECH,
Islamabad
5. Prof. Dr. Anwar-ul-Hassan, Member
Department of Soil Science,
University of Agriculture,
Faisalabad,
6. Mr. Muhamamd Jamil Khan, Member
Department of Soil Science,
Faculty of Agriculture,
Gomal University, D.I. Khan,
7. Prof. Dr. Muhammad Bashir Chaudhry, Member
Dean/Principal
University College of Agriculture,
Rawalakot, AJ & K,

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| 8. | Prof. Dr. Muhammd Yousaf,
Department of Soil Science,
Arid Agriculture University,
Rawalpindi, | Member |
| 9. | Dr. Muhammad Abid,
Assistant Professor,
University College of Agriculture,
B.Z. University,
Multan | Member |
| 10. | Dr. Allah Bakhsh
Assistant Director
On-Farm Water Management
Pehur High Level Canal Project
Mardan | Member |
| 11. | Prof. Dr. Muhammad Jamal Khan,
Chairman,
Department of Water management,
NWFP Agricultural University,
Peshawar | Member/Secretary |

Meeting started with recitation from the Holy Quran.

Mr. Muhammad Riaz Cheema, Director, Higher Education Commission, Regional Centre, Lahore welcomed the participants on behalf of Chairman, Higher Education Commission. He briefed the committee about the responsibility of the Higher Education Commission for revision of curricula of all subjects taught at graduate and post graduate level in the universities and affiliated colleges in the country. The Director, also requested the members to include latest books in the draft curriculum.

The Committee unanimously appointed Prof. Dr. Muhammad Latif as Convener and Prof. Dr. Muhammad Jamal as its Secretary.

Prof. Dr. Muhammad Jamal briefed the committee about the objectives, background, achievements and problems faced by the Department with the present degree programme. He stressed for uniformity so that the students of Department of Water Management should be able to compete for jobs with the students of similar disciplines in other universities. Dr. Nisar A. Memon supported Dr. Jamal's point of view to bring the curriculum at par with the other universities so the students may have engineering background with specialization in Water Resources Management. Dr. Latif suggested B.Sc

Engineering degree with specialization in Water Resources Management, which was accepted by the committee.

The Committee also prepared scheme of studies for postgraduate level where as the details of courses for postgraduate degrees programme the same was further refined and developed in the light of recommendations of the committee by the Department of Water Management, NWFP Agricultural University, Peshawar and was sent to all the committee members for comments and suggestions. The graduate and postgraduate programmes were finalized in next meeting held during April 2003 in Lahore. The committee recommended the following scheme of studies for graduate & postgraduate levels. Details of courses for graduate level in the subject of "Water Resources Management" with General Recommendations are also given as under:

**PROGRAMME OF STUDY
FOR
B.Sc ENGINEERING DEGREE IN
WATER RESOURCES MANAGEMENT**

Course No.	Title of the Course	Credit Hours
FIRST SEMESTER		
WRM-301	Introduction to Water Resources Management	3 (3,0)
WRM-303	Engineering Surveying	3 (2,2)
WRM-305	Engineering Drawing and Graphics	3 (1,4)
WRM-307	Basic Agriculture	4 (3,2)
WRM-309	Mathematics-I	3 (3,0)
WRM-311	Fluid Mechanics-I	4 (3,2)
WRM-313	Writing and Communication Skills	3 (3,0)
WRM-315	Islamic Studies	3 (3,0)
		26

SECOND SEMESTER

WRM-302	Land Leveling	4 (3,2)
WRM-304	Engineering Drawing of Water Projects	3 (1,4)
WRM-306	Mathematics-II	3 (3,0)
WRM-308	Engineering Materials	4 (3,2)
WRM-310	Engineering Mechanics	4 (3,2)
WRM-312	Thermodynamics	3 (2,2)
WRM-314	Pakistan Studies	2 (2,0)
WRM-316	Economics for Engineers	3 (3,0)
		26

Course No.	Title of the Course	Credit Hours
THIRD SEMESTER		
WRM-401	Strength of Materials	4 (3,2)
WRM-403	Information Technology Application in Water Resources Management	3 (3,0)
WRM-405	Fluid Mechanics-II	4 (3,2)
WRM-407	Theory of Structures	4 (3,2)
WRM-409	Soil Physics	4 (3,2)
WRM-411	Farm Power and Machinery	4 (3,2)
WRM-413	Workshop Practices	3 (1,4)
		<hr/> 26 <hr/>

FOURTH SEMESTER

WRM-402	Hydrometry	4 (3,2)
WRM-404	Engineering Geology	4 (3,2)
WRM-406	Soil Mechanics	4 (3,2)
WRM-408	Salt Affected and Waterlogged Soils	4 (3,2)
WRM-410	Computer Programming and Applications	3 (2,2)
WRM-412	Soil, Plant and Water Relations	4 (3,2)
WRM-414	Rural Sociology	3 (3,0)
		<hr/> 26 <hr/>

Course No.	Title of the Course	Credit Hours
FIFTH SEMESTER		
WRM-501	Foundation Engineering	3 (2,2)
WRM-503	Surface Water Hydrology	3 (3,0)
WRM-505	Participatory Irrigation Management	4 (3,2)
WRM-507	Soil and Water Conservation Engineering	4 (3,2)
WRM-509	Surface Irrigation Methods	4(3,2)
WRM-511	Fundamentals of Remote Sensing and GIS	4 (3,2)
WRM-513	Environmental Engineering	4 (3,2)
		26

SIXTH SEMESTER

WRM-520	Ground Water Hydrology	4 (3,2)
WRM-504	Open Channel Hydraulics	4 (3,2)
WRM-506	Soil Survey and Land Use	4 (3,2)
WRM-508	Statistics	3 (3,0)
WRM-510	Water Quality Management	3 (2,2)
WRM-512	Water Supply and Sanitation	4(3,2)
WRM-514	Plain and Reinforced Concrete	4 (3,2)
		26

Course No.	Title of the Course	Credit Hours
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SEVENTH SEMESTER

WRM-601	Pressurized Irrigation Systems	3 (2,2)
WRM-603	Irrigation Engineering	4 (3,2)
WRM-605	Watershed Management	3 (2,2)
WRM-607	Pumps and Tube Wells	3 (2,2)
WRM-609	Project Planning and Management	3 (3,0)
WRM-611	Drainage Engineering	4 (3,2)
WRM-613	Quantity Survey and Estimation of Water Projects	3 (1,4)
WRM-615	Instrumentation	3(2,2)
		26

EIGHTH SEMESTER

WRM-602	Internship	12 (0,24)
WRM-604	Project and Report	4 (1,6)
WRM-606	Survey Camp (Four weeks)	4(0,8)
		20

**TOTAL CREDIT HOURS FOR THE DEGREE PROGRAMME:
202**

DETAIL OF COURSES

FIRST SEMESTER

WRM-301 INTRODUCTION TO WATER RESOURCES MANAGEMENT
3 (3, 0)

THEORY:

Introduction: importance of water resources management in Pakistan, major components and functions of water resources management. **Water Resources of Pakistan:** sources of water, overview of surface and ground water resources of Pakistan, hydrological and agro-hydrological cycle, water use in agriculture, problems and extent of irrigated and rainfed land, potential of surface and ground water availabilities, major sustainability issues, unit of measurement. **Climate and Weather:** temperature variation, rainfall, humidity and evaporation, agro-climatic zones of Pakistan, weather station, site selection, measurement of weather elements, effect of weather elements on plant growth. **Irrigation Systems:** irrigation system network, major canal and headworks in Pakistan, Large scale, dug well, civil canal and mountain, Rod Kohi and Karez irrigation system, water distribution schedules, participatory irrigation management, objectives, approach, merits and demerits of irrigation system. **Irrigation Application Methods:** classifications, surface (border, contour border, check basin and furrow irrigation) and pressurized irrigation system (sprinkler and trickle irrigation), water harvesting. **Water Resources Management:** federal level (WAPDA and ISRA), provincial level (PIDA and Agricultural Department), community managed irrigation and private irrigation system, Rod-Kohi and flood irrigation system management system.

BOOKS RECOMMENDED:

1. De bont, Michael. 1993. Water in Agriculture. Department of Water Management, NWFP Agricultural University, Peshawar.
2. Ahmad, N. 1993. Water Resources of Pakistan, Shahzad Nazir, 61 B/2, Gulberg , III, Lahore, Pakistan.
3. Ahmad,N and Ghulam Rasul Chaudhry. 1988. Irrigated Agriculture of Pakistan. Shahzad Nazir, 61 B/2, Gulberg , III, Lahore, Pakistan.

WRM-303 ENGINEERING SURVEYING
3(2,2)

THEORY:

Introduction: types of surveying, instruments used, precision and accuracy theory, construction and uses of chains, steel bands, optical square, box sextant,

Preparation of Drawings in first and third angles of orthographic projection of parts such as nuts and bolts, keys and cotters, screw thread systems, couplings, simple bearings and pipe connection of detailed and a few assembly drawings.

BOOKS RECOMMENDED:

1. Parkinson A.C. 1998. A First Year Engineering Drawing, Sir Isaac Pitman & Sons Ltd., London.
2. French, T.E. and C.J. Vierch. 1992. A Manual of Engineering Drawing, McGraw Hill Book Co. New York.

WRM-307

BASIC AGRICULTURE

4(3,2)

THEORY:

Agriculture and its Importance: sciences allied to agriculture, classification of field crops. Ecological zoning of different crops: cropping pattern and cropping intensity. Tillage: Primary and secondary tillage practices. Fertilizers: farm manures, green manuring, organic matter and fertilizers in improving soil fertility and productivity. Suitability of crops with respect to soils. Crop Production: general principles, applications of modern agro, techniques to major cereal crops, fibre crops, sugar crops, oil seed crops, pulses, fodders, vegetables, climate, pure seed, time of sowing, seed rate, irrigations, fertilizer requirements, harvesting and post harvest care. Crop Protection: Insect pest diseases and weed control of major crops.

PRACTICAL:

Identification and study of various crops grown in the vicinity. Identification of seeds of various crops. Identification of various commercial fertilizers and manures. Use of common hand tools and indigenous machines used in farming. Identification of weeds, types of insecticide and herbicides.

BOOKS RECOMMENDED:

1. Shafi Nazir 1994. Crop Production. National Book Foundation, Islamabad, Pakistan.
2. Martan, 1990. Principles of Field Crop Production, McMillan Co. Inc. New York.
3. Riaz, S.A. 2000. Crop Production in Pakistan, Deptt. Of Agriculture, Punjab.
4. B. Allah, 2002. Crops of Pakistan, Sindh Agriculture University, Tandojam.
5. Govt. of Pakistan, 1997. A Manual of Irrigation Agronomy Vol. I, Federal Water Management Cell, Islamabad.

WRM-309

MATHEMATICS-I

3(3,0)

THEORY:

Revision of Elementary Differentiation: Cartesian and polar coordinate systems, hyperbolic functions, catenaries, exponential and logarithmic function. Application of Derivatives. rate, speed, acceleration. tangents and normals. Maclaurian's and Taylor's series. Maxima and minima of a function of single variable. Convexity and concavity (points of inflexion) and errors due to small increments. Curvature and radius of curvature. Partial differential coefficient. Partial differentiation of an implicit function. Total differential and its application to small errors. Statement of Taylor's theorem. Maxima and minima of function of two independent variables. Introduction to Integration: integration by substitution and by parts, definite integral, double and triple integral and their use in determining area, volume, centroid and moment of inertia. Application of integral. Area under a curve. Mean and root mean square values. Length of an arc. Areas of surfaces and volumes of solids of revolution. Theorems of Pappus and Gladius. Approximate integration for areas and volumes. Prismoidal rule for volumes of irregular solids, tanks, cuttings and embankments. Graphical differentiation and integration with examples of engineering application.

BOOKS RECOMMENDED

1. Yousaf, S.M. and M. Amin. 1985. Calculus with Analytical Geometry
2. Thomes, B. G. 1987. Calculus & Analytical Geometry.

WRM-311**FLUID MECHANICS-I****4(3,2)****THEORY:**

Properties of Fluids: density, viscosity, surface tension, bulk modulus of elasticity, compressibility of fluids, system of units, laws of conservation of energy and mass. Fluid Statics: pressure variations in a fluid, pressure measuring devices, gauges and manometers, buoyancy and stability of submerged and floating bodies, pressure on immersed surfaces, depth of centre of pressure on immersed surfaces. Fluid Kinematics: types of flow, continuity equation Bernoulli's equation and its practical application, cavitation, hydraulics and energy grade lines, energy of fluids in motion, fluids particle in motion, flow nets. Energy Consideration in Steady Flow: general equations of steady flow, heads, hydraulics and energy grade lines, power consideration, fluid flow, losses of head. Fluid Measurements: orifices, weir and notches, derivation of discharge formulae and their application.

PRACTICAL:

Conversion of units of fluid flow, determination of density, specific weight, specific gravity, measurement of pressure by manometers, differential gauges and piezometers, determination of metacenter and center of buoyancy, verification of Bernoulli's equation, measurement of flow through venturimeter, measurement of velocity with Pilot tube.

BOOKS RECOMMENDED:

1. Daughterty, R.L., J.B., Franzini, and E.J., Finnemore. 1995. Fluid Mechanics with Engineering Application. McGraw Hill Book Co., Singapore.
2. Streeter, V.L. 1988. Fluid Mechanics. McGraw Hill Inc., New York.
3. Jain, A.K. 1990 Fluid Mechanics: A text book for engineering students, Khana Publisher, New Delhi, India.

WRM-313 WRITING AND COMMUNICATION SKILLS 3(3,0)

Writing formal and business letters and memos. Drafting notices and minutes. Theoretical knowledge and comprehension of contracts and agreements. Preparing proposals and conducting and writing research project reports. Participating in seminars and interviews. Writing and presenting Conference papers.

WRM-315 ISLAMIC STUDIES 3(3,0)

***** As prescribed by HEC *****

SECOND SEMESTER

WRM-302

LAND LEVELING

4 (3,2)

THEORY:

Introduction: learning objectives and the setup of the course, the relevance of surveying and leveling for water management. Leveling: leveling, instruments, their working and uses, reduction of levels, classification of leveling. Differential Leveling: introduction, leveling equipment, leveling procedure, profile leveling of main and lateral conveyance channels. Precision Land Leveling and Watercourse Command Area: definition, benefits of land leveling, procedure of land leveling, equipments, laser leveling equipments. Computation of Areas and Volume: measurement of area, general methods of measurement, planimeter, measurement from cross sections, measurement from contour lines, mass diagram, areas and volumes of regular and irregular figures, the mid ordinate, average ordinate, trapezoidal and Prismoidal's rules for areas and volumes, borrow pits.

PRACTICAL:

Surveying of a sample filed for land leveling, volume of cut and fill calculation, laser guided field leveling exercise.

BOOKS RECOMMENDED:

1. Kanetkar, T.P., and S,V, Kulkarni, (not dated), Surveying and Leveling, Union Book Stall. Karachi.
2. Ministry of Food, Agriculture & Cooperatives, (1986), On Farm Water Management Field Manual, Vol. 2: Precision Land Leveling, Water Management Wing, GOP. Islamabad.

WRM-304

ENGINEERING DRAWING OF WATER PROJECTS 3(1.4)

THEORY & PRACTICAL:

Introductory Aspects: need and requirement of drawings for water project, general nature of drawings, components, symbols and nomenclature needed for specific drawings. General description of drawings related to water projects. Structural Drawings: elements of structural drawing and detailing, preparation of foundation plan, structural framing, details, staircase details, water tanks, beam and column elevations and sections mostly pertaining to reinforced concrete structures. Computer Aided Drawing (AutoCAD): general and basic know how related to computer aided drafting, e.g. coordinate system, drawings setup procedure, basic draw commands, basic edit commands, layers, creating test and defining styles options, block and drawing import/export options; cross hatching, save and plot (2D) and isometric drawings, computer drawing (CAD & CAM),

graphs and graphical computation, alignment charts, empirical equations, graphical mathematics.

BOOKS RECOMMENDED:

1. James, H.E. 1995. Engineering Design Graphics, Addison Wisley Publishing Co. Massachusetts.

WRM-306

MATHEMATICS-II

3(3,0)

THEORY:

Differential equations: first order and special types of higher order differential equations of engineering application, The D-operator, complementary function and particular integral, simultaneous differential equations, solution of differential equations in series. Fourier Series: Fourier theorem and coefficient in Fourier series, even and odd functions. Laplace Transforms: Laplace transform of some elementary functions, Laplace transform theorems, Inverse Laplace transforms, application to solution of ordinary differential equations. Partial Differential Equations: solution of simple types of differential equations, partial differential equations in cylindrical and spherical coordinates.

BOOKS RECOMMENDED:

1. Sharma, G.S., K.L.Ahuja and I.J.S. Sarna.1988. Advanced Mathematics for Engineers and Scientists

WRM-308

ENGINEERING MATERIALS

4(3,2)

THEORY:

Stone and Marble: their hardness, uses, classification characteristics of good building stone, important building stones, examination and testing of stone. Bricks: brick material, harmful constituents of brick material, preparation and burning of bricks, tests and characteristics of good bricks, tiles and terra cotta. Lime and Mortars: lime classification and uses, lime and its handling precaution. Mortars: type of mortars, object of mixing sand in mortars and concrete, test for mortars, precautions in the use of mortar, grouting, gypsum and plaster of Paris. Cement: different types of cement, manufacture of cement, dry and wet process, practical test of cement. Crushed Stone/Pebbles Aggregates: fine and coarse aggregates, harmful materials, functions of deferent constituents of mortars. Concrete: lime concrete, cement concrete, water cement ratio, proportioning of concrete mixes, placing, compaction and curing of concrete, qualities of good concrete. Timber: types of timber their characteristics and uses. Plastics: types and properties of plastics, use of plastic in building construction, sewerage, water supply, irrigation and drainage systems, tunnel system etc. Tar, Bitumen and Asphalt: general tar, crude and coal tar pitch, bitumen, asphalt, tests for tar and bitumen.

PRACTICAL:

Identification of different engineering materials, classes and characteristics of bricks, identification, classes, and separation of aggregates, preparation of mortar paste, consistency test of cement, preparation of concrete, compressive and tensile strength

BOOKS RECOMMENDED:

1. Haider, S.Z. 1985. Materials of Construction (2nd edition), Oxford University Press, Pakistan.
2. Surendra S. 1990. Engineering Materials. Vikas Publishing House (Pvt) Ltd. 5 Ansari Road, New Delhi 110002.

WRM-310**ENGINEERING MECHANICS****4(3,2)****THEORY:**

Force systems: use of unit vectors, cross product, dot product, resultant of coplanar and concurrent forces, resultant of non-coplanar and concurrent forces, moment of a force, resultant of non-coplanar and non-concurrent forces, coplanar and non-coplanar applications, couples, resultant of any force system. Equilibrium of Force Systems: free body diagrams, equations of equilibrium for concurrent and non-concurrent force systems, equilibrium of planar systems, equilibrium of spatial systems. Analysis of forces by the method of joints and method of sections. Centre of gravity: centre of gravity of rigid bodies (3 coordinate system), centroids of weights, lines, areas and volumes, centroids of composite areas, theorems of pappus. Friction: theory of friction, square threaded screws, belt friction and transmission of power. Absolute motion: rectilinear, angular and curvilinear motions, motion of projectiles and rigid bodies. Relative Motion: relative displacement, velocity and acceleration, instantaneous centres. Force and Energy: force, mass and acceleration of rigid bodies. Work and Energy: work done by system of forces, potential and kinetic energy of particles, principle of work and kinetic energy, conservation of energy, power and efficiency. Impulse and Momentum: principle of linear impulse and momentum, principle of angular impulse and momentum, conservation of linear and angular momentum.

PRACTICAL:

Verifying the law of polygon of forces, the law of parallelogram of forces, the principle of moments, the coefficient of friction between surfaces, extension and compression of springs, moment of inertia of fly wheel mounted on wall and a wooden block by bifilar suspension, efficiency of various models of machines, modulus of rigidity of metal bar by static and dynamic method, special numerical problems and assignments.

BOOKS RECOMMENDED:

1. Riley, W.F. and Sturges, C.D. 1996. Engineering Mechanics; Statics and Dynamics, John Wiley & Sons Inc., New York.
2. Meriam, J.L., and Kraige, L.G. 1993. Engineering Mechanics. Statics, Vol. 1 and Dynamics Vol. 2, John Wiley and Sons, New York.
3. Bedford, A. and Fowler, W., 1994. Engineering Mechanics: Statics: Statics and Dynamics, Addison, Wesley Publishing Company, New York.
4. McGill, D.J. and King, W.W., 1994. Engineering Mechanics: Statics and Dynamics, PWS Publishing Co., New York.

WRM-312**THERMODYNAMICS****3(2,2)****THEORY:**

Heating and Expansion of Gases: units of heat, gases and vapors, constant volume and constant pressure, PV diagram, specific heat of gases, internal energy of gas, law of conservation of energy, heating and expansion of gases and vapors, work done by gas in expansion laws of perfect gases, laws of thermodynamics for different types of heating methods. Air Cycles: cycles of operation, air standard efficiency of a cycles, reversible process, and cycles, reversibility and efficiency, Carnot cycle, Otto cycle, Diesel cycle, mean effective pressure, entropy of gases, entropy and heat, T-Q diagrams of Carnot, Otto, Diesel and dual combustion cycles. Air Compressors: types, functions, conditions for maximum efficiency of reciprocating and rotary compressors, effect of cylinder clearance. Compound Expansion: advantages of compound expansion, tandem type of two-cylinder compound engine, receiver type of compound engine; combined indicator diagram for compound engine, calculations for cylinder uniflow engine. Fuels: combustion of fuels, conversion of energy, volumetric analysis, analysis by weight, weight of carbon in burnt gases, weight of air required for complete combustion of fuel, weight of flue gases per pound of fuel burnt, weight of excess air supplied, method of analyzing flue gases, heat carried away by flue gases, air fuel ratio for I.C. engine. Nozzles: nozzle shape; critical pressure ratio; maximum mass flow or checked flow, nozzles for the design pressure ratio, nozzle efficiency. Properties of Steam: enthalpy of water, dryness fraction, latent heat, enthalpy of wet steam, use of steam tables, superheated steam, internal energy of steam, steam plant, condensers, steam turbines, gas turbines.

PRACTICAL:

Study of working principles of two stroke and four stroke engines (in the lab.), verification of Joule's law, study the performance of rotary and reciprocating air compressors and their characteristics curves, PV diagram of diesel engine, study of exhaust gas analyzer, analysis of exhaust gases, performance and investigation of nozzles.

BOOKS RECOMMENDED:

THIRD SEMESTER

WRM- 401

STRENGTH OF MATERIALS

4(3,2)

THEORY:

Simple Stresses and Strains: introduction, types of stresses and strains, elastic limit, modulus of elasticity, yield point, factor of safety, stresses in composite bars and rivet joints, stresses due to change of temperature> Elastic Constant: Young's modulus, shear modulus, bulk modulus, Poissons ratio and relation between elastics constants, mechanical properties of materials. Compound Stresses and Strains: methods for the determination of stresses on oblique sections, use of Mohr's circle to stress problems, and failure theories; moment of inertia; bending stresses in beams, theory of simple bending, bending moments and shear forces in beams, derivation of flexure formula and section modulus. Torsion: torsion theory for shafts of circular section, power transmitted by shaft, torsion combined with bending, open and closely coiled helical springs subjected to axial loading, deflection of beams, area moment method and Castigliano's theorem, stresses in thin cylinders and spherical shells, strain gages.

PRACTICAL:

Simple tension test of iron, steel and their stress-strain diagram, compression test on steel and cast iron with stress-strain diagram; test of riveted joint, study of torsion by means of measuring load and deflection of helical springs, including stress-strain diagram, bending moment, deflection, load curves and calculation of beams; testing of long steel column; flexure test of wooden beams.

BOOKS RECOMMENDED:

1. Muvdi, B.B. & W. McNabb. 1984. Engineering Mechanics of Materials, McMillan Publishing Co., New York.
2. Shigley, J.E. and L.D. Mitchell, 1983. Mechanical Engineering Design.

IN WATER RESOURCES MANAGEMENT**THEORY & PRACTICAL:**

Introduction: Importance and scope of IT in water resources management. Information Technology: Introduction to information system and information technology, functions, data and instruction, translating from human intentions to machine instructions, role of computer in information technology, types of computers, computer architecture, coding, inputting, storing, retrieving and displaying data, operating system software, types of computer networks. Net working: electric communication and WWW, integrated office as general toolbox for text, spreadsheet, important website for information and research related to water sector in the world, searching of universities offering degree program in water resources related discipline. Web Sites: development of web sites by WYSIWIG or by any other suitable editor, illustrations and examples of custom-made programmes and programming (VBA in spreadsheet as an example), examples in statistical analysis etc. Engineering Graphics: introduction, data presentation with engineering graphics, introduction to computer graphics, ingredients of computer graphics, girding and digitizing data, engineering graphics software and their use in creating two and three-dimensional graphs. CAD: Auto CAD use in design of water projects.

BOOKS RECOMMENDED:

1. Marco, J.B., R. Harboe and J.D. Salas. 1993. Stochastic Hydrology and its use Water Resources Systems Simulation and Optimization. Kluwer Academic Publishers, Dordrecht.
2. Turban, E. and E. McLean. 1999. Information Technology for Management: Making Connections for Strategic Advantage, John Wiley and Sons Inc. USA.
3. Alter, S. 1999. Information System, a management perspective. 2nd ed. The Benjamin/Cummings Publishing Co.
4. Heam, D. and M.P. Baker. 1998. Computer Graphics. 2nd ed. Prentice Hall of India New Delhi.
5. Hill, F.S. Jr. 1990. Computer Graphics, Macmillan Publishing Co., New York.

THEORY:

Momentum and Forces in Fluid Flow: impulse momentum principles and application, force exerted on a stationary and moving bodies (flat and curved), reaction of a jet, jet propulsion, torque in rotating machines. Similitude and Dimensional Analysis: geometric, kinematic, and dynamic similarity, dimensionless numbers Reynolds and Froude number, and their application,

application of similitude and dimensional analysis in hydraulic model studies. Steady Incompressible Flow in Pressure Conduits: laminar and turbulent flow in circular pipes, major and minor energy losses in pipes, branching of pipes, pipes in series, pipes in parallel and pipe network analysis. Flow in Open Channel: Chazy, Bazin and Francis formulae, hydraulic control and measurement structures back water calculations. Hydraulic Turbines: types of turbines, suitability and components of turbines, inlet and outlet velocity diagrams, guide blade angle, inlet and outlet vane angles, WHP and BHP of turbines, hydraulic, mechanical and overall efficiencies of turbines, factors influencing the performance of turbines.

PRACTICAL:

Impact of jet on stationary flat and curved vanes, measurement of various losses in pipes, measurement of shock losses, determination of losses in union, elbow, bends crosses, tees, verification of Reynolds number.

BOOKS RECOMMENDED:

1. Daugherty, R.L., J.B., Franzini, and E.J., Finnemore. 1995. Fluid Mechanics with Engineering Application. McGraw Hill Book Co., Singapore.
2. Streeter, V.L. 1988. Fluid Mechanics. McGraw Hill Inc., New York.
3. Jain, A.K. 1990 Fluid Mechanics: A text book for engineering students, Khana Publisher, New Delhi, India.

WRM-407

THEORY OF STRUCTURES

4(3,2)

THEORY:

Analysis of indeterminate structures by the application of the methods of three moments, slope deflection, column analogy and conjugate beam, soil bearing properties and design of foundation, structural columns with concentric and eccentric loads, theory and design of reinforced concrete beams, slabs and columns, bond and shear stresses.

BOOKS RECOMMENDED:

1. Wang, C.K. 1992. Indeterminate Structural Analysis. McGraw Hill Book Co., New York.
2. Wang, C.K. and Charles. 1995. Reinforced Concrete Design, Herper and Row Publications, New York.
3. James, L.M. 1996. Concrete Technology, Mcdonald and Edward (Longman Group), London.

WRM-409

SOIL PHYSICS

4(3,2)

THEORY:

Physical Properties of Soil: texture, structure, density, porosity and water content. Soil water Potential: components, soil water retention curves, hysteresis. Water Movement in the Soils: Darcy's law, unsaturated and saturated hydraulic conductivity, water flow under unsaturated condition, natural drainage, field water balance, infiltration factors affecting infiltration and infiltration models. Air and Vapor Movement in Soil: heat flow and energy balance. Soil Degradation: soil compaction and crusting.

PRACTICAL:

Soil water retention curve, determination of bulk density, determination of hydraulic conductivity, infiltration rate.

BOOKS RECOMMENDED:

1. Jury, W.A, W.R. Gardner and W. H. Gardner, 1991. Soil Physics 5th ed. John Wiley and Sons, Inc, New York, U.S.A,
2. Hillel, D. 1982. Introduction to soil physics. Harcourt Brace Jovanoich, New York, U.S.A.
3. Hanks, R.J. 1992. Applied Soil Physics. 2nd Edition, Springer Verlag, New York, USA

WRM-411

FARM POWER AND MACHINERY

4(3,2)

THEORY:

Farm Power: type of tractors, practical engine cycles and timing, engine components, electrical systems, spark ignition system, fuel system and carburetion, diesel engines, cooling system, lubricants and lubrication system, hydraulic system, power transmission system, hydraulic system, repair and maintenance. Tillage Equipment: Primary and secondary tillage equipments, seedbed preparation, planting equipments, direct frilling. Farm Machinery: classification of farm machinery, objectives and scope, earth moving machine, scraper, road roller, leveling equipment, laser leveling equipments, shovels, pipe layers, bulldozer excavators, trenchers, backhoe, trench plows, wheel trenchers, graders and auto graders, cranes, maintenance of farm machineries.

PRACTICAL:

Disassembly of different engines, analysis of disassembled engine reassembly, engine tests, field operation of machinery, adjustment of farm machinery and equipment, visits to Agricultural Engineering and Machinery Management workshops.

BOOKS RECOMMENDED:

1. Bainer, R., B.A. Kepner and E.L. Barger. 1992. Principles of Farm Machinery, John Wiley and Sons. Inc. New York, USA
2. Mosses, B.E. and B.F. Kenneth. 1991. Farm Power, John Wiley and Sons, New York.

WRM-413**WORKSHOP PRACTICES****3(1,4)****THEORY:**

Properties and Processes of Metals: ferrous metals, iron ores, properties and use of pig iron, cast iron, wrought iron, steel, standard processes of manufacturing of iron and steel, open hearth process, oxygen processes, production of ingots. Alloy Steel and Irons: effect of the alloying elements, the AISI/SAE alloy steel and their identification, corrosion resistance steel, steel for high temperature services. Non-ferrous Metals: properties and use of copper, aluminum, zinc, tin, nickel, and lead. Non-ferrous alloys: copper, aluminum, zinc base, nickel base, lead tin alloys, iron carbon equilibrium diagram. Heat Treatment: Heat treatment theory and process, annealing, hardening, tempering, normalizing, surface hardening, quenching, heat treatment equipments. Work on Metals: measurement of surface, metal cutting, filing, chipping, drilling, reaming, thread cutting with taps and dies. Welding: definition, types of welding processes, welding equipment. Arc welding; current rating, welding materials, arc welding processes, inspection and testing of welded joints, gas welding, welding flames and materials, cutting of metals, use of gas welding. Foundry: definition, importance, advantages and disadvantages of foundry, casting, hand molding tools, characteristics, molding sand, foundry cores, properties of core sand, crucibles, handling and care, cupola furnace, construction, zone of cupola and its advantages.

PRACTICAL:

Safety and first-aid, safety in workshop, electrical, mechanical and other accidents, safety measure and devices, safety in the use of different hand tools, exercise in arc and gas welding, soldering and brazing, metal cutting, selection of tools for welding process, study tours to concerned industries.

BOOKS RECOMMENDED:

1. Chapman W.A.J. 1996. Workshop Technology part I, Edward Arnold Publishers. Ltd., London.
2. De Garmo, E.P..1989. Materials and Processes in Manufacturing. The McMillan Company 866 Third Avenue, New York.
3. Atkins, E.A. and A.G. Walker. 1988. Electric Arc and Oxyacetylene Weldings 4th edition, Sir Isaac Pitman Sons, London.
4. Heavy D. M. 1990. Exploring Pattern Making and Foundry. The McMillan Company 866 Third Avenue, New York.

FOURTH SEMESTER

WRM-402

HYDROMETERY

4(3,2)

THEORY:

Introduction: definition of hydrometry, importance and scope of hydraulic measurements in water resources management, unit of flow measurement. Water Levels: types of gauges, selection of gauge sites, water level gauging stations, automatic recording systems, stilling wells, accuracy in measurements, presentation of result of water level measurements, telemetry system. Measurement of Bed Levels: position fixing, sounding, data processing. Discharge Measurements: methods of discharge measurement, velocity area method (current meter and float method), slope area, dilution, data processing, rating curves, selection of methods. Measurement of Sediment Transport: sediment yield, classification of sediment transport, instruments, sampling techniques. Flow Measuring Structures: types and function of structures, classification of flow measuring structures, head, discharge relationship.

PRACTICAL:

Use of different equipment and techniques for flow measurement in the field, their evaluation and data analysis.

BOOKS RECOMMENDED:

1. Bolten, W., (1990), Hydrometry, Wageningen Agricultural University, The Netherlands.
2. Bos, M. G., (1989), Discharge measurement structures. ILRI publication No. 20, The Netherlands..
3. Kraatz, D. B. and I. K. Mahajan, (1982), Small hydraulic structures. FAO Irrigation and Drainage paper 26 Vol.1 and 2.
4. Government of Pakistan, (1986). On farm water management flow measurement, Vol. III, Federal Water Management Cell, Islamabad.

WRM-404

ENGINEERING GEOLOGY

4(3,2)

THEORY:

Introduction: internal constitution of the earth, importance of geology for water projects, geological processes (external & internal), rock cycle, volcanoes, physical properties of common rock forming minerals. Geological Material: type of rocks and their formation process, common rock forming processes, type of soil and their formation process, types and geology of aquifers. Geological Classification: identification of rocks by geologic name and local name, identification of subordinate constituents in rock samples, such as seams, or brands of other type of minerals, e. g. dolomitic limestone, calcareous sandstone, sandy limestone, etc. Durability of rocks: drying and wetting test, slake durability test, soundness test. Engineering and Physical properties of rocks: specific gravity and absorption, unit

weight, uniaxial compression strength, moisture content etc. Earthquakes: causes and effects of earthquake, index for earthquake. Applied Geology: role of geology in selection of sites for dams, reservoirs, selection of tunnel sites, land slides, introduction to blasting. Glaciers and Glaciation: brief introduction of local geology, geological map reading, bore log interpretation.

PRACTICAL:

Identification of rocks and minerals, field trips to different rocks formation and dam sites.

BOOKS RECOMMENDED:

1. Elsevier, R.B., 1984. Geology in Engineering, Applied Science Publication, London and New York.

WRM-406

SOIL MECHANICS

4(3,2)

THEORY:

Introduction: soil properties, void ratio, porosity, specific gravity, saturation, submerged density, Atterberg limits and measurements. Soil Water: hygroscopic, capillary, gravitational, pore water; state of stresses on soil mass: seepage, flow net analysis. Shear Strength: Coulomb's equation and failure theory, measurement of shear strength, triaxial test. Earth Pressure: kinds of lateral earth pressures, Rankine earth pressure theory, stability of slopes, stability analysis of infinite and finite slopes, methods of slices, types of soil stabilization. Retaining Walls: definition, purpose and classification, some possible forces acting on earth retaining structures, lateral earth pressure, Coulomb's earth pressure theory, assumptions, deficiencies in Coulomb's earth pressure theory, methods of force projection, active earth pressure, derivation of active earth pressure, passive earth pressure, derivation of passive earth pressure, stress distribution diagram, various kinds of surcharge. Bearing Capacity of Soil: Factors affecting bearing capacity, classification of foundations, method of determining bearing capacity, load and settlement, design of footings; compaction in relation to foundation and stability: factor affecting compaction, Proctor test and modified Proctor test, consolidation.

PRACTICAL:

Sieve analysis, specific gravity test, Atterberg Limit tests, compaction test, capillary head test, consolidation test, shear strength test, triaxial compression test.

BOOKS RECOMMENDED:

1. Jumikis, A.R. 1994. Soil Mechanics, D.Van Nostrand Company Inc., Princeton, New Jersey.
2. Terzaghi, K. 1997. Soil Mechanics in Engineering Practice. John Wiley & Sons, New York.

3. Smith, G.N. 1990. Elements of Soil Mechanics. BSP Professional Books Oxford.

WRM-408 SALT AFFECTED AND WATERLOGGED SOILS 4(3,2)

THEORY:

Salt Affected Soils: types, extent and causes, origin of salt in soils, origin and nature of saline and sodic, alkali and waterlogged soils, exchangeable bases and cation exchange in soil, soil reaction, solute movement of water in soil, pH value of soil and its significance. Soil Reclamation: reclamation techniques, saline soils leaching requirements, amendments for sodic soils, gypsum requirements. Management of Salt Affected Soils: provision of surface, subsurface or vertical drainage, salt tolerance crops, agronomic practices, manures, irrigation practices. Management of Waterlogged Soils: causes, extent and remedial measures, effect of waterlogging on plant growth, management of waterlogged soils, irrigation water quality effects on soil environment.

PRACTICAL:

Measurement of infiltration rate of saline, sodic and waterlogged soils, movement of solutes, preparation of soil paste and soil saturation extract, chemical analysis for pH, EC, SAR, ESP, and cations and anions, quality of irrigation water, water table depth measurements.

BOOKS RECOMMENDED:

1. Abrol, I., J.S.S.P Yadav and F.I. Masood, 1988. Salt affected soils and their management. Soil Bull. 390. FAO. Rome Italy.
2. Bresler, E., B.L. McNeal and D.L. Carter. 1982. Saline and Sodic Soils, Principles, Dynamics, Modeling. Springer, Verlag, New York.
3. Tanji, K.K. 1990. Agricultural salinity assessment and management. ASCE No.71, New York, USA.
4. Gupta, I.C. 1990. Use of saline water in Agriculture. Oxford and IBH Pub. Co., New Delhi, India.

WRM-410 COMPUTER PROGRAMMING AND APPLICATIONS 3(2,2)

THEORY:

Introduction: computer components, computer codes, computer operating system (DOS, WINDOWS , UNIX, etc.), data input/output devices, data Storage devices, computer software & application (word processing, spread sheet, engineering graphics). Programming: programming languages, types of characters, sub-routines and functions, flowchart, programming structure, introduction to Fortran, application of Fortran to solve engineering problems.

PRACTICAL:

Demonstration of computer components and operating system, exercise on the use of word processing, spread sheet and engineering graphics, programming of engineering problems with Fortran.

BOOKS RECOMMENDED:

1. Shelly and Cashman. 1996. Using Computer, a Gateway to Information. Boyd and Fraser Publishing Company, USA.

WRM-412 SOIL, PLANT AND WATER RELATIONS 4 (3,2)**THEORY :**

Introduction: importance of soil plant and water relations, molecular and fluid properties of water. Soil, plant and water relationships: water potential and its components. Soil,water relation: energy concept. Texture and structure, porosity and density, water retention characteristics curve and hysteresis, Field capacity, wilting point, available water. Flow of water in soil. Infiltration, redistribution, drainage and runoff. Plant, water relation: rooting characteristics, water uptake by plants, transport of water in plants, transport of nutrients in soil and plants. Atmosphere, water relation: evapotranspiration (ET) and factors influencing it.

PRACTICAL:

Determination of water content by direct and indirect methods. Determination of field capacity and water retention characteristics.

BOOKS RECOMMENDED:

1. Mengel, K. and E.A. Kirkby. 2001. Principles of Plant Nutrient, 5th Edition, International Potash, Instt. Bern, Switzerland
2. Teare, I.D., and M.M Peet, (1983), Crop,Water Relations, John Wiley and Sons New York, USA.
3. Hillel, D., (1982), Introduction to Soil Physics. Academic Press.,Orlando, FL., USA

WRM- 414 RURAL SOCIOLOGY 3(3,0)**THEORY :**

Studying the Group Dynamics: Types of social groups, primary and secondary groups, In, groups and out, groups, reference group; group dynamics; group size, leadership, social loafing, social dilemmas, group thinking, conformity. Types of disputes; dispute resolution techniques; Participatory Irrigation management; Organizational Techniques for Sustainable social organizations; A case Study; Community development: Adoption process case studies.

BOOKS RECOMMENDED:

1. James, W. and Vander Zanden. 1988. The Social Experience: An Introduction to Sociology. Random House, New York.
2. Robertson, I. 1989. Society: A Brief Introduction. Wroth Publisher, New York.
3. Starkloff, R., D. J. Bandaragoda, M.A. Cheema and M.A. Bhatti, 1999 Social Organization for improved system management and sustainable irrigation Agriculture in Mirwal and Shahpur Small Dams. Pakistan National Program International Irrigation Management Lahore Report No.R,80.

FIFTH SEMESTER**WRM-501****FOUNDATION ENGINEERING****3(3,0)****THEORY :**

Foundations: definition, purpose and types, General requirements of foundations, Depth of footings, Selection of foundation type, Dewatering of foundations for construction. Vertical Stresses in Soils: definition, foundation materials, stresses caused by self weight of soil, Geostatic stresses, Stresses caused by point loads and uniformly distributed loads: Boussinesq and Westergaard theories , Pressure bulb , stress distribution diagram on horizontal and vertical planes. Bearing Capacity: definition, Sources of obtaining bearing capacity, Presumptive values, Plate load test and standard penetration test, Terzaghi's and Meyerhof's theories of bearing capacity, effect of load eccentricity on bearing capacity, Effect of Water table on bearing capacity, Factors effecting bearing capacity. Foundation Settlement: definition, types, components, causes and remedial measures. Consolidation Settlement: Mechanics of consolidation by spring analogy, Terzaghi's one dimensional consolidation Theory, Compression index, Coefficient of compressibility and Coefficient of volume change, Determination of Preconsolidated Pressure, Degree of consolidation, Time rate of consolidation settlement , Determination of coefficient of consolidation , Primary and secondary consolidation, Estimation of Consolidation settlement for footings.

BOOKS RECOMMENDED:

1. Qureshi, M. S., 1996. Fundamental of Soil Mechanics, A-One Pub. Al-Fazal Market Urdu Bazar, Lahore.
2. Peck, R. B., W.E. Hanson and T. H. Thotburn, 1984, Foundation Engineering, Wiley Eastern Ltd. New Delhi, India.

WRM-503**SURFACE WATER HYDROLOGY****3(3,0)**

THEORY :

Hydrologic Processes: introduction, the hydrologic cycle, importance of hydrology, weather, general circulation, temperature, humidity, wind, precipitation, forms and measurement of precipitation, interpretation of precipitation data, variation in precipitation, snow cover and snow fall, stream flow, water stage, discharge, interpretation of stream flow data, evaporation and transpiration, factors controlling evaporation, estimates of evaporation, evaporation control. Hydrologic Analysis: precipitation analysis, factors affecting runoff, Characteristics of hydrograph, components of runoff, recessions, hydrograph separation, runoff relations, phenomena of runoff estimating the volume of storm runoff, estimating snow melt runoff, seasonal and annual runoff, relations, hydrographs of runoff, unit hydrograph, its derivation and application, overland flow. Hydrologic Routing: river routing, linear reservoir model, Muskingam method.

BOOKS RECOMMENDED:

1. Wilson, E. M., 1990, Engineering Hydrology. Macmillan Civil engineering hydraulics.
2. Linsely, R.K., Kohler, J.L.H. Paulhyus, 1996, Hydrology for Engineers. McGraw Hill Kogaskusha Ltd.
3. Awan, N.M., 1981, Surface Water Hydrology, National Book Foundation, Islamabad.
4. Ward, R.C., Robinson, M. 1990. Principles of Hydrology, McGraw Hill Book Co., London.

WRM-505 PARTICIPATORY IRRIGATION MANAGEMENT 4 (3,2)**THEORY :**

Introduction: concept, importance and need for the involvement of the users in the process of irrigation development and operation. Farmers' participation in irrigation systems: strategies for approaching farmers over time: to do to, to do for, to do with; development of irrigation systems, integrated rural development, target group development; framework of Cohen and Uphoff. Target groups in irrigation: selection of target groups. Practical methods to communicate with farmers: diagnostic analysis, problem solving model, effective methods to communicate with farmers about irrigation topics. 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: need of water users' associations in Pakistan, problems and constraints in establishment of water users association, experiences of a project which tried to set up water users associations, the Water Users' Association Act of Pakistan.

PRACTICAL:

Students will work on PIM case, studies applied. Each student will conduct and report an interview with farmer(s) on the topic of Water Users Associations.

BOOKS RECOMMENDED:

1. 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.
2. Korten, F. F. and R. Y. Siy, Jr., 1989. Transforming a Bureaucracy: The Experience of the Philippine National Irrigation Administration, Ateneo De Manila University Press.

WRM-507 SOIL AND WATER CONSERVATION ENGINEERING 4(3,2)**THEORY :**

Introduction: importance and scope of soil and water conservation. Soil erosion: types, water wind and gravity erosion. Precipitation: rainfall characteristics related to erosion. Watershed: definition, watershed characteristics. factors affecting infiltration and runoff, importance of infiltration in soil and water conservation. Water Erosion and Control Practices: factors affecting erosion by water, types of water erosion, mechanics of erosion, forms of water erosion, soil loss equation and its components, soil loss estimation and erosion control practices. Wind Erosion and Control Practices: the mechanics of detachment, transport and deposition of soil or practical, estimation of soil loss by wind erosion control practices. Vegetated Waterways: use, design and maintenance of vegetated waterways. Terracing, functions, classifications, design, location and maintenance of terrace. Conservation Structures: types, functional requirements and limitations of conservation structures. Embankments and Farm Ponds: types, foundation requirements and design of earth embankments, water harvesting concepts, site selection and design of farm ponds. Agronomic practices: tillage, contour farming, strip cropping, cover crops.

PRACTICAL:

Measurements of soil loss from splash erosion by rainfall simulator. Measurements of runoff and runoff coefficient of field plots. Measurements of soil loss under different rainfall intensities. Demonstration of moisture conservation techniques. Field visit to soil and water conservation sites.

BOOKS RECOMMENDED:

1. Schwab, G. O., R. K., Fervert, T.W., Edminister, and K.K., Barends.1993. Soil and Water Conservation Engineering. John Wiley & Sons New York.
2. Frederic R. Troch. 1991. Soil and Water Conservation. Printice Hall, Englewood Cliff. New Jersey, USA.
3. Hudson, N. 1976. Soil Conservation. BT Batsford Limited. Morga R.P.C.
4. Linsely, R.K. and F. Joseph. 1996. Water Resources Engineering. McGraw Hill.

THEORY:

Introduction: basic concepts of surface irrigation, advance and recession curves, advances ponding (wetting), depletion and recession phases; difference between surface irrigation and pressurized irrigation, irrigation efficiency, irrigation uniformity (distribution uniformity), factors affecting irrigation efficiency and uniformity. Type of surface irrigation methods: basin, border, furrow, flooding, surge and other innovative techniques. Irrigation delivery schedules: crop, based, continuous and rotational water supply schedules, constant vs variable water supply, evaluation of irrigation systems

PRACTICAL:

Excursions showing various surface application methods, exercise in determining furrow and border length under different circumstances, determination of the application efficiency of different application methods.

BOOKS RECOMMENDED:

1. Walker, W.R. and Skogerboe, G.V. 1987. Surface irrigation, theory and practice,
2. Larry G. James, 1988., Principles of Farm Irrigation System Design.
3. Ch. R.A. 2001. Irrigation and drainage practices methods for irrigation requirements, University of Agriculture, Faisalabad.

THEORY :

Remote sensing: electromagnetic radiations, Radiation laws, Radiometric terms and units. Type of remote sensing sensor; Spectrometers radiometers, Sensor calibration, Multi,spectral Scanners, Real and synthetic aperture radars. Platforms and data used in remote sensing: Orbital elements of satellite, Remote sensing satellite, Digital data, Ground data, Image processing and interpretation: Image processing systems, Image correction, Re,sampling, Image enhancement, Spatial filtering, Principal component analysis, classification techniques. GIS and its applications. Use of GPS.

PRACTICAL:

Interpretation of Land use/Land cover. Use of GPS.

BOOKS RECOMMENDED:

1. Murai, S. 1997. Remote Sensing Note. Japan Association on Remote Sensing, Tokyo.

2. Barrett, E.C. and Curtis, L.F. 1992. Introduction to Environmental Remote Sensing. 3rd edition Chapman & Hall, London.
3. Foody, G. and Gurrán, P. 1993. Environmental Remote Sensing from Regional to Global Scales. Jhon Willey & Sons, England.

WRM-513

ENVIRONMENTAL ENGINEERING

4(3,2)

THEORY:

Introduction: environment and its pollution, sources of pollutions, Greenhouse effect, environmental issues of global concern. Sources of Pollutants: agro,chemical, municipal waste, industrial and other, Dust pollutants, metal, gas and vapor pollutants. Industrial, vehicular and tobacco smoke and biological agents. Water Pollution: sources, industrial waste treatment and sewage treatment, environment impact assessment. Impact of pollutants on soil, water, plant, animal and human health. Radiation and Health: effects of microwave radiation, ultra violet radiation and laser radiation on environment and health. noise pollution. Management and Control: public awareness, control measure at source, soil and water treatment and others.

PRACTICAL:

Determination of chlorine concentration, alkalinity, dissolved oxygen, bio,chemical oxygen demand, pH, turbidity, residual chlorine, suspended solids and dissolved solids of a sample of water. Measurements of NO₃ in waste water. Visit of various Industries to study the pollution monitoring and control equipment.

BOOKS RECOMMENDED:

1. Vesilind, P.A. J.J. Peirce and R.T. Weiner. 1990 Environmental Pollution and Control. Butterworth,Heinemann, London.
2. Pandey, G.N. and G.C. Carney. 1992. Environmental Engineering. Tata McGraw Hill Publishing Company Limited, New Delhi.
3. Wall, J.D. 1980. Environmental Management Hand Book. Welf Publishing Co., London, Tokyo
4. Henry, J.G. and G.W. Heinke, 1989. Environmental Science and Engineering. Prentice Hall Ltd.
5. Sincero, A.P. and G.A. Sincero, 1999. Environmental Engineering: A Design Approach.

SIXTH SEMESTER

WRM-502

GROUND WATER HYDROLOGY

4(3,2)

THEORY :

Introduction: basic concepts of groundwater and soil water, types of subsurface water, water potential, aquifer types, soil water movement and ground water movement. Forms and origin of groundwater, aquifer functions, porosity, storage coefficient, hydraulic conductivity, transmissivity. Groundwater Movement: Darcy's law and its applications, observation wells, piezometers, flow nets, streamlines, equipotential lines, steady and non steady flow. Well Hydraulics: steady flow in confined and unconfined aquifers, steady flow in confined aquifer with uniform recharge, unsteady flow in unconfined aquifer, wells near aquifer boundaries, multiple well system, specific capacity, well losses, well efficiency and aquifer testing. Wells: test holes and well logs, methods for constructing well, methods for drilling wells, well development, design of wells and gravel packing, various methods of ground water exploration.

PRACTICAL:

Water level measurements by electric sounding. Determination of groundwater flow rates and direction. Determination of well losses and well efficiency. Determination of aquifer characteristics. Demonstration of an available ground water computer model.

BOOKS RECOMMENDED:

1. Johnson. 1988. Ground Water and Wells. Johnson and Co. USA.
2. Ranghunath, H.M. 1987. Groundwater, Willy Eastern Ltd., Singapur.
3. Bouwer, H. 1996, Groundwater Hydrology, McGraw Hill Inc. New York.
4. Ahmed, N. 1985. Ground Water Resources of Pakistan, Shahzad Nazir Publisher, Gulberg,III, Lahore.

WRM-504

OPEN CHANNEL HYDRAULICS

4(3,2)

THEORY :

Basic Concepts of Fluid Flow: types, state and regimes of flow, channel types, channel geometry, measurement of velocity in channel, velocity distribution in channel and its coefficients, pressure distribution in channel, effect of slope on pressure distribution. Energy and Momentum Principles: basic equations, specific energy, specific energy and alternate depths, E,Y relationship, criteria for a critical state of flow, computation of critical flow, control of flow, application of flow control in rectangular channel, momentum in open channel flow, specific momentum, hydraulic jump, M,Y relationship. Uniform Flow: establishment of

uniform flow, the Chezy and Manning's equations, resistance coefficient estimation, normal depth and velocity, normal and critical slopes, free board, best hydraulic section, determination of section dimensions. Rapidly Varied Flow: characteristics of varied flow, sharp crested weir, aeration of the Nappe; crest shape and discharge cover spillway, type and characteristics of the jump, location of jump, jump as energy dissipater, flow through sudden transitions.

PRACTICAL:

Determination of discharge of an open channel by weirs and flumes. Application of specific energy and momentum functions. Y,Q relationship. E,Y relationship. Determination of Chezy C and Manning's 'n' for a rectangular channel. Laboratory study of hydraulic jump and alternate depth.

BOOKS RECOMMENDED:

1. French. R.H. 1996. Open Channel Hydraulics. McGraw,Hill International Book Company
2. Henderson, F.M. 1990. Open Channel Flow. Macmillian Publishing Co., Inc.
3. Chow, V.T. 1973. Open Channel Hydraulics. Mc. Graw,Hill International Book Company.
4. Chadwick, A., Mortelt, 1993. Hydraulics in Civil and Environmental Engineering E & FN Spon, London.

WRM-506

SOIL SURVEY AND LAND USE

4(3,2)

THEORY:

Introduction: importance of soil maps, purpose and characteristics, interpretation of soil maps. Types of soil maps: exploratory, reconnaissance, semi, detailed and detailed. Aerial Photographs: types, mosaics and topographic maps, characteristics, Aerial photo interpretation, pattern analysis, elements analysis, land forms , relief, drainage pattern vegetation and colour tone, mapping legend. Soil Survey Report: Basic principles, interpretation of soil survey data. Land Capability: classification, classes, subclass and units, land suitability classifications, land qualities and utilization, land evaluation.

PRACTICAL:

Reading and interpretation of soil maps, Stereoscope, types parts and their use and interpretation of aerial photographs, Description of soil profile.

BOOKS RECOMMENDED:

1. Soil Survey Division Staff, 1993. Soil Survey Manual , USDA, US Govt. Printing Office, Washington D.C, U.S.A.
2. FAO, 1967. Aerial photo interpretation in soil survey, Soils Bulletin, No. 6, FAO, Rome, Italy.
3. Smith, A. J. 1970, The preparation of soil survey reports. Soil Bulletin No. 9 , FAO, Rome, Italy.

WRM-508

STATISTICS

3(3,0)

THEORY:

Introduction to statistics: graphic representation of statistical data; measures of central tendency and dispersion, introduction to probability; addition and multiplication theorems of probability; the binomial, poisson and normal distribution, sampling theory, sampling distribution of means, and the difference between two means, applications of F, t and chi,square distributions; regression analysis; simple, partial and multiple correlation; applications of Analysis of Variance.

BOOKS RECOMMENDED:

1. Muhammad, F. 1999. Statistical Methods and data analysis; Kitab Markaz, Bhowana Bazar, Faisalabad, Pakistan.
2. Ronald E. Walpole. 1982. Introduction to Statistics; McMillan publishing Co., Inc. New York. 10022.
3. Choudhry, S.M. and S. Kamal. 1998. Introduction to Statistical Theory Part I & II; Ilmi Kitab Khana, Kabir Street, Urdu Bazar, Lahore 54000.
4. Lester D. Taylor. 1974. Probability and Mathematical Statistics. Harper & Row, Publishers New York, Eranston San Francisco London.
5. Miller I. and John E. Freund. 1985. Probability and Statistics for Engineers. Prentice Hall, Inc., Englewood Cliffs, New Jersey.

WRM-510

WATER QUALITY MANAGEMENT

3(2,2)

THEORY:

Introduction: definition and concepts, irrigation and drainage water quality, water quality terminology, water quality objectives, quality criteria and standards for irrigation water carcinogenic/non carcinogenic substances water quality status in Pakistan. Water Treatment: water pollution and their sources, water treatment techniques i.e. coagulation, softening, mixing and flocculation, sedimentation, filtration etc.Drainage Effluents and Management Techniques: sources of drainage water, characteristics, quality of drainage water, alternates for disposal of drainage water drainage water reuse techniques, crop management, soil management techniques, chemical management techniques, drainage and leaching fractions, concepts of preferential flow. Wastewater Treatment: heavy metals, waste water microbiology, characteristics of domestic waste water primary and secondary wastewater treatment, land treatment, sludge treatment and disposal. Agricultural chemicals and Groundwater Contamination: agricultural chemical, their uses, trends and properties concept of nitrate nitrogen and pesticides transport ;through the soils, behavior of

agricultural chemicals in flooded/water logged soils, management practices to avoid groundwater contamination.

PRACTICAL:

Analysis of drainage water for irrigation, Wastewater analysis for BOD, COD and other chemicals. Visit of wastewater treatment plants, drainage system and water reuse sites.

BOOKS RECOMMENDED:

1. McKenzie, L. D. and A. Cornwell 1991. Introduction to Environmental Engineering.
2. Tyagi, O.D. and M. Mehar, 1990. Environmental Chemistry, Report No.103. Agriculture and groundwater quality. Form Council for Agricultural Science and Technology.
3. Rosenberg, N.J., B. L. Blad. 1983. Microclimate, the biological environment. 2nd edition, John Wiley and Sons, N.Y.

WRM-512

WATER SUPPLY AND SANITATION

4(3,2)

THEORY:

Introduction: overview of water supply and sanitation in Pakistan; Health Aspects of Water Supply and Sanitation; Water availability standards. Water Supply: sources of water, Choices of water sources (spring, wells etc) and their protection. Design and construction of Tubewells, Dug wells and handpumps. Forecasting population, Consumption for various purposes, Factor effecting consumption, Analysis Impurities in water, Physical tests, chemical tests, Bacteriological tests. Economics of community water supply, Planning and design of low cost water supply schemes. Water Treatment and Distribution : sedimentation tank, Coagulation, Flocculation, Usual coagulants, Mixing devices, Filtration, Filter sand, Classification of filters, disinfections, Chlorination. Sanitation: purpose of sanitation, Site for sewage treatment work, Water borne and helminth diseases and their control, Health and water chemistry, Planning and design of low cost sanitation. Composting and biogas, sanitation and irrigation, Agriculture and aqua cultural reuse.

PRACTICAL:

Assessment of water supply demand of a community, Design of a water supply project Determination of physical, and chemical characteristics of drinking water, Determination of Bacteriological characteristics (Coliform count) of water and waste water. Visit to a drinking water treatment plant.

BOOKS RECOMMENDED:

1. Steel, W. Ernest. 1999. Water supply and Sewerage. McGraw Hill Book Co. USA.

2. Cairncross, S. and R.G. Feachem. 1993. Environmental Health Engineering in the Tropics. John Wiley and Sons, Inc., New York .
3. Feachem, R.G., M. McGarry, and D. Mara, 1977. Water, Wastes and Health in Hot Climates. John Wiley & Sons, Inc., New York,
4. & Sons, Inc., New York,

WRM-514

PLAIN AND REINFORCED CONCRETE

4(3,2)

THEORY:

Concrete Technology: constituent materials concrete & their properties, Hydration, setting & hardening of cement. Testing of cement & aggregates. Types of concrete & their properties. Batching, mixing transportation & placing of concrete, Properties of fresh & hardened concrete & factors affecting them. Testing of concrete for various properties including physical & strength tests. Introduction to RCC : basic principles of reinforced concrete design and associated assumptions; Behaviour of reinforced concrete members in flexure; Design philosophy, design codes, factor of safety and load factors; Prevailing methods of design of reinforced concrete members. Working stress methods : serviceability criteria and checks for deflection, crack width and crack spacing; Importance of working stress method related to prestress. Ultimate strength methods : analysis and Design of prismatic and non, prismatic sections in flexure, compatibility based analysis of sections and code requirements for flexure; Analysis of one, way and two way solid slabs with general discussion on other slab systems; Design for flexure. Shear stress in reinforced concrete sections, models and analogies towards solution of diagonal tension problem; Design for diagonal tension. Design and detailing for bond, anchorage, development length, laps and splices.

PRACTICAL:

Concrete slump test, Concrete compression test, consistency test, material quality assessment.

BOOKS RECOMMENDED:

1. Nilson, A. H. 1997. Design of concrete structure, International Edition, The McGraw Hill Company. Inc. New York. USA.
2. Farman and S. Ali. 1982. Plain reinforced concrete design., Farooq Kitab Ghar, Karachi, Pakistan
3. Mallick and A. P. Gupta. 1984. Reinforced concrete, 2nd Edition, IBH Publication, New Dehli, India.

SEVENTH SEMESTER

WRM-601 PRESSURIZED IRRIGATION SYSTEMS 3(2,2)

THEORY:

Sprinkle Irrigation: objectives, advantages and disadvantages of sprinkle irrigation and trickle irrigation. Types of sprinkle irrigation systems: portable, semi, permanent and permanent systems, set move irrigation system, hand move, tow move, side roll and gun type, center pivot sprinkle system, sprinkle systems components. Principles of sprinkle system design: System layout, sprinkle design, sprinkler selection, sprinkle system evaluation, pressure requirements for set sprinkler systems. Trickle Irrigation: trickle irrigation methods: drip, subsurface, bubbler and spray irrigation system, components of drip irrigation, emission devices. Design of trickle irrigation: system layout, selection of emission devices. Control of trickle system clogging: filtration, settling basin, media filter, screen filter, chemical treatment, evaluation of trickle irrigation systems. Low Head Pipelines: 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.

PRACTICAL:

Design of a small sprinkle irrigation system, selection of sprinklers, and evaluation of sprinkle systems. Design of a small drip irrigation system, selection of proper emitter, and evaluation of drip irrigation systems. Visit to a sprinkle and trickle irrigation project sites..

BOOKS RECOMMENDED:

1. Keller, J., and R.D. Bliesner, 1990. Sprinkle and Trickle Irrigation, Van Nostrand Reinhold.

WRM-603 IRRIGATION ENGINEERING 4(3,2)

THEORY :

Introduction: definition, Necessity of Irrigation, concept and scope of irrigation engineering, Benefits and ill effects of Irrigation. Irrigated Agriculture: crop base period, Duty and Delta of crop, Relationship between duty and delta, Factors on which duty depends, Depth and frequencies of irrigation, Kharif , Rab ratio, Optimization of irrigation water, Irrigation efficiencies, Uniformity co,efficient, Consumptive use of Water, Effective rain fall, Net irrigation requirements. Field irrigation requirement, Gross Irrigation Requirement. Canal Irrigation System: alluvial and Non alluvial soil/canals; alignment of canal; distribution system for canal irrigation, Basic definitions, Determination of required canal capacity, Canal losses, Evaporation, Seepage, empirical formula for channel losses,

channel section for minimum seepage loss. cross drainage works. Design of Irrigation Channel: design of stable channel, Regime Channels, Kennedy's theory, critical velocity ratio, Kutter's formula, Manning's formula, Lacey's theory, Design procedure for Lacey's theory, Estimation of transported sediment, bed load equations, Meyer, Peter's and Einstein's formula, Muneer and Qureshi formula. Diversion Head Works: difference between a weir and Barrage, Layout of diversion head works. The diversion weir, Types and components of diversion weir, The canal head regulator, canal regulation and silt control at the head works. Theories of Seepage and Design of Weir and Barrage: causes of failure by piping and direct uplift, Safety against piping and uplift, Bligh's Theory, Lane's theory, Khosla's theory and concept of flow nets Stream lines and equipotential lines, Critical gradient, Khosla's method of independent variables for determination of pressure and exit gradient below a weir or barrage, Khosla's simple standard profiles, Design examples of barrage, head regulator, etc. Cross regulator its design, Canal outlets or Modules, Types of modules.

PRACTICAL:

Excursion to canal irrigation systems, different irrigation structures, design of canal system, design of outlets and watercourses.

BOOKS RECOMMENDED:

1. Ali, I. 2000. Irrigation and hydraulic structures (3rd Edition). Institute of Environmental Engineering & Research. NED University of Engineering and Technology, Karachi, Pakistan.
2. Meijers, T.K., 1990, Design of Small Holder Irrigation Systems, Wageningen Agricultural University, the Netherlands.
3. Horst, L. 1998. The dilemmas of water distribution. International Irrigation Management Institute., Srilanka

WRM- 605

WATERSHED MANAGEMENT

3(2,2)

THEORY:

Introduction: importance and role of watershed management , issues and constraints in watershed management socio, technical approaches for development, sustainable integrated watershed management concepts and approaches to Participatory Watershed Management : overview of recent approaches, New developments in socio, economic concepts, Small vs big watershed development and biodiversity, Conflict Management. 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, natural resource management, bio,technology of natural resource Management, Water Harvesting and Water Management. Water harvesting Practices: micro,catchment development in

Pakistan & Worldwide. Catchment area ratio and grid spacing. Land development techniques. Runoff Estimation, Reducing runoff losses, Agronomic practices, Land surface modification, Contour bunding, Contour trenches, Hillside Conduit System, Reducing Evaporation, Reducing Losses from Reservoirs, Forcing Deep Water Penetration, Reducing Deep Percolation Losses, Chemical Treatment, antitranspirants

PRACTICAL:

Field study trips to watershed areas, small dams sites and other watershed project sites and writing reports

BOOKS RECOMMENDED:

1. Bhatta, B.R., Chalise, S.R., Myint, A.K., and Sharma, P.N. 1999. Recent Concepts, Knowledge, Practices & New skills in PIWM. Dept. of Soil Conservation and Watershed Management, Nepal.

WRM-607

PUMPS AND TUBE WELLS

3(2,2)

THEORY :

Occurrence of Ground Water: sources of ground water, types of aquifers; source of recharge to ground water. Types of Flow: non, steady and steady flow, flow to fully and partially penetrated wells; mechanics of well flow; factors affecting quantity of flow. Hydraulic Design of Well: estimation of aquifer loss, estimation of well loss; design of well screen, design of filter. Construction of Tube Well: components of a tubewells, well drilling methods, selecting and setting of screens, design and placing of gravel pack, methods of well development, tube well performance tests. Pumps and Equipments: types and selection of pumps, Design of pumps, pump characteristics curves; Pump material; trouble shooting; pump maintenance, skimming wells; Experience of tube wells in Pakistan.

PRACTICAL :

Identification of components of tube well and trouble shooting, well logging, Draw down measurements, measurement of discharge, visit to a drilling and test site of a tube well.

BOOKS RECOMMENDED:

1. Ahmad, N., 1995. Groundwater Resources of Pakistan, Shahzad Nazir Publisher, Gulberg, III, Lahore.
2. Ahmad, N., 1995. Tubewell Theory and Practices, Shahzad Nazir Publisher, Gulberg, III, Lahore.
3. Johnson. 1988. Ground Water and Wells. Minnesota, USA.

THEORY :

Project Planning, Scheduling and Controlling by Deterministic Models: project planning activities, Rectangular bar chart, CPM, developing a critical path schedule, determining the minimum total cost of a project, Manual versus computer analysis of critical path methods, preparing a execution schedule, scheduling resources, delivering Materials, scheduling laborers, Financing the project, Job layout, Project control during construction, keeping equipment records, Project supervision. construction cost control, cost control records. Project Planning, Scheduling and Controlling by Probabilistic Models: PERT project Evaluation & Review Technique, Statistical tools as mean variance. Standard Deviation. Probability distribution, beta courses, center limit, Use of computer software in project management and planning. claims and arbitration: claims, escalation, indexation, arbitration and litigation. Factors Affecting the Selection of Equipment and Tools: standard types of equipment, special equipment, the cost of owning and operating equipment, depreciation cost, straight line depreciation, decline balance method, sum of the year, digit method, Investment costs, operating costs, economical life of construction equipment, cost of depreciation and replacement, Maintenance and repair costs, down time costs, economical cost of equipment, sources of construction equipment. .labour problems, labour organization, prevention and settlement of disputes.

THEORY :

Drainage Problems: drainage systems in Pakistan and their extent. Current drainage practices; benefits of drainage; occurrence of water in the soil, source of excess water, pressures in the soil water, water table, ground water flow (Darcy's Law), saturated flow theory, flow through stratified soils, hydraulic conductivity and its measurement, drainable pore space; salinity and water movement; leaching requirements; drainage requirements; Surface Drainage: design of open ditches; methods of construction; different ditch systems; maintenance of open drains. Interceptor drains and their design. Subsurface drainage: Tile drains, mole drains; depth and spacing. Design criteria (steady and non steady state); drainage coefficient; length and size of the tile drains. Outlets for tile drains; Vertical Drainage: design and material. sump and pumps, experience of vertical drainage in Pakistan; subsurface drainage materials: tile drain pipes, plastic, lined mole drains, types of filter mole drains, loads on conduits, types of filter envelopes, design of filter envelope; drainage machinery: trencher and trench less plows, back hoe, automatic grade control.

PRACTICAL:

Verification of Darcy's Law by laboratory methods; determination of water table, saturated hydraulic conductivity by piezometers and auger hole methods, visit to

PRACTICAL:

Measurement of displacement by LVDT and potentiometer, IHP and BHP of tractor and tractor,drawn equipment, force by strain gages, pressure in IC engine cylinder, temperature by thermocouples.

BOOKS RECOMMENDED:

1. Daily, J.W., W.F. Riley and K.G. Connel. 1994. Instrumentation for engineering measurement. John Willey and Sons Inc. New York.
2. Doebelin, E.O. 1996. Measurement Systems: Application and Design. 3rd ed., McGraw,Hill Book Co., New York.

EIGHT SEMESTER

WRM-602 INTERNSHIP 12(0,24)

WRM-604 PROJECT AND REPORT 4(1,6)

Introduction to technical report writing, important components of technical writing, presentation methods and skills, selection/preparation for seminar, research topic, objectives, review of literature, methodology, data processing, results, conclusions, summary, abstract, presentation of (data collected in the field/laboratory) results in the form of graphs, tables, figures, and photographs, references and appendices, writing of report and presentation.

WRM-606 SURVEY CAMP 4(0,8)

**SCHEME OF STUDIES FOR M. Sc. AND Ph. D.
IN ENGINEERING (WATER RESOURCES MANAGEMENT)**

Course No.	Course Title	Cr. Hours
WRM-701	Advanced Hydrology	4(3,2)
WRM-702	Design of Irrigation Systems	4(3,2)
WRM-703	Water Resources Management	3(3,0)
WRM-704	Design of Drainage systems	4(3,2)
WRM-705	Environmental Impact Assessment	3(2,2)
WRM-706	Design of Farm Irrigation Systems	3(2,2)
WRM-707	Waste Water Treatment	3(2,2)
WRM-708	Mathematics-III	3(3,0)
WRM-709	Applied Statistics	4(3,2)
WRM-710	Hydrometeorology	3(3,2)
WRM-711	Operation and Management of Irrigation and Drainage Systems	3(2,2)
WRM-712	Application and Use of Computer Modeling in Water Resources	3(1,4)
WRM-713	Integrated Watershed Management	4(3,2)
WRM-714	Design of Dams	4(3,2)
WRM-715	Water Management Computations	4(2,4)
WRM-716	Research Operation and Management	2(2,0)
WRM-717	Reservoir Operations	3(2,2)
WRM-718	River Engineering	3(3,0)
WRM-719	Flood Estimation and Control	3(3,0)
WRM-720	Sedimentation Engineering	3(2,2)
WRM-721	System Analysis	3(3,0)
WRM-722	Ground Water Exploration	3(3,0)
WRM-723	Ground Water Modeling	3(1,4)
WRM-794	Seminar-I (M. Sc.)	1(1,0)

5. Todd, D. K, 1995, Groundwater Hydrology, 2nd edition John Wiley & Sons, New York, U.S.A

WRM- 702

DESIGN OF IRRIGATION SYSTEMS

4(3,2)

THEORY:

Introduction: Learning objectives and set-up of the course, relevance of irrigation systems for water management in the light of irrigation technologies and socio-technical approach to enhance productivity & reduce poverty. Design of Irrigation system: Data requirements for design of irrigation system, Layout of main canal, irrigation channels, and outlets. Flow measurement; determination of losses in irrigation system. Irrigation scheduling. Dynamic crop response model. Modeling of Irrigation Schedules. Methods of surface and sub-surface irrigation; their suitability and economics in water saving. Economics of lined channels. Irrigation efficiencies. Project efficiency, operation efficiency and economic efficiency. Diagnostic analysis of Irrigation systems: Development model. System perspectives. Interdisciplinary approach. Identification of problems. Establishment of objectives. Allocation of responsibility. Information collection. Development of work plans and methods. Technical, social and economic data. (Collection. Data analysis. Report writing. On-farm management; practices; physical constraints, socio-economic problems. Traditional practices. Comparative study of watercourse improvement. Management Concepts: Basic concepts from organization and management sciences, Irrigation & Poverty alleviation. Conceptual Frame Work of Irrigation System Mgt: Policy, Main system, Tertiary units, Irrigation system analysis and water delivery Policy. Performance Evaluation: Different concepts of performance, Productivity, Equity, Stability and Well-being. Domains of irrigation. Organizational Structures: Irrigation Institutions in Pakistan. Formal & Informal Rules. Deficiencies in the present institutional framework. Dominance of informal rules.

PRACTICAL:

Design and layout of selected irrigation systems, field evaluation of an irrigation system, evaluation of irrigation system by using computer software.

BOOKS RECOMMENDED:

1. Bandaragoda, D.J. 1992. Institutional Factors Affecting Irrigation Performance in Pakistan. International Irrigation Management Institute. IIMI Country Paper-Pakistan-No.4
2. Chambers, Robert. 1992. Managing Canal Irrigation. Oxford & IBH Publishing Co. Pvt. Ltd.
3. Reader "Organization of WM" developed in Dept. of Water Management, N-W.F.P. Agricultural University Peshawar.
4. Richard A Smith. 1970. Management Structure for irrigation. Journal of Irrigation and Drainage Division. ASCE. Pp 475-487.

THEORY:

Physical setting of area: Physiography and physical Drainage system, Geographical distribution and status of irrigated agriculture, climate (season of Monsoon in different parts, Atmospheric pressure conditions and precipitation, Rainfall variability, climate logical water balance), soil types, Geology and Land Resources. Cultural setting of area: Demographic setting of the area, Agricultural Economy (land use and cropping pattern), Industrial Economy (food product, textile, chemical etc.) Sources means of supply and assessment of water resources. Surface water resources utilization and potential: History of development of irrigation system; Indus Water Treaty 1960; IBP works and their role in water management; present integrated surface water management. Bank storage and negotiation; Water Apportionment Accord. Designing of irrigation canals and Warabandi system, application of irrigation water and its management, problems of irrigated agriculture of Pakistan., Utilization and management of surface water resources, Means of supply (pumps canals, pump canals, rivers). Assessment of water resources (rivers, ponds) total available water. Ground Water Resources utilization and potential: Groundwater development potential; potential water savings from irrigation system; water application efficiencies, Groundwater mining, water table control, artificial recharge. Types of wells, public tube wells, private wells, Persian wheel, open wells, management and utilization of ground water, characteristic features of ground watertable measurement of observation wells, depth of water table, form of W.T, fenosim of watertable), Assessment of Ground Water Resources (Recharge of groundwater). Quality of Water. General standard of quality of water for different uses (Domestic, Irrigated TDS, soil and index EC, Industrial, permeability index), Conjunctive use of surface and groundwater. Water use requirement and associated problem: Constraints, water use and requirements. Area under different means of irrigation (canal, private and public tubules, pumping set, Persian wheel, masonry wheels). Crop wise irrigated area, Intensity of irrigation, utilization of water in Irrigation, water requirement of crops, livestock requirement, total water use and requirement. Problem related to water use. Floods and water logging causes, Flood control measures, (Bunds, and cross drainage), draught and water scarcity area, soil salinity and alkalinity. Conservation and planning of Water Resources: Conservation of water resources (checking the water losses, conjunctive use of surface and Ground Water Resources), planning for future development (irrigation, livestock and total) water consumption in 2002.

BOOKS RECOMMENDED:

1. Summaries of Irrigated Agriculture of Pakistan by Dr. Nazir Ahmad and Ghulam Rasool Chaudhary
2. Contribution of Private Tubewells in the development of water Potential by NESPAK(1991)

THEORY:

Introduction: Drainage requirements and objectives; effect of drainage and salinity on crops yield; the nature and extent of waterlogging and salinity problems in Pakistan; Sources of excess water, relationship of irrigation and drainage; Diagnosis of drainage/ salinity and selection of control practices. Effects of waterlogging and salinity on soils and plants: plants response to waterlogging saline and sodic conditions, Economic of salt tolerant crops; salt affected soils and waters, soil responses to saline and sodic conditions, irrigation water quality assessments, leaching fraction, control of root zone salinity, crops salt tolerance, crop production functions special and temporal variability in salinity. Drainage Systems: Surface drainage system, factors affecting surface runoff, design layout, maintenance of surface drainage system; Sub-surface drainage system, design, layout, materials, pipe size, envelope materials, construction of drainage structures; maintenance of Vertical drainage system. Drainage projects and investigation: Project preparation, drainage survey, observation wells and piezometers, processing of data; maps and reports, project monitoring and evaluation. Land reclamation, treatment and disposal of drainage water: Use of saline drainage water for irrigation, drainage water treatment and disposal options, institutional and local constraints, and economic incentive and environments quality. Drainage and Salinity Management Options: On farm irrigation and drainage practices, Management of dry land saline seeps, project level waterlogging and salinity management options.

PRACTICAL:

Field sampling and monitoring of soil, water, plants; measurements techniques in drainage and salinity management; use of dynamic optimization models in salinity and drainage management.

BOOKS RECOMMENDED:

1. Ritzema, H.P., 1994, Drainage Principles and Application, ILRI Publication No. 16. 2nd edition, Wageningen, The Netherlands.
2. Abro;, I.P., J.S.P. Yadv, F.I. Masood, 1988. Salt affected soils and their management. FAO soils Bulletin 39, Tome.
3. Reeve, Charles and J. Watt, 1990. Ground water drought, pollution and management by Charles Reeve and Jacqueline watts editors

THEORY:

Overview of environmental impact assessment; selection of scientific, engineering, and socio-economic factors in environmental impact assessment: environmental impact indicators, national policy alternatives. Identification of quantitative and qualitative environmental evaluation criteria; application of traditional and other techniques for assessing impacts of predicted changes in environmental quality. Approaches for identifying, measuring, predicting, and mitigating environmental impacts; modeling techniques employed in environmental impact assessment. Environmental standards and the environmental impact assessment process: and methodologies for incorporating environmental impact assessment into management decision-making.

PRACTICAL:

Students learn to prepare an environmental impact assessment, review and critically analyze an environmental impact statement, use mathematical models for environmental impact prediction, and apply environmental impact assessment as a tool in management decision-making. Case studies of environmental impact assessment for selected projects (hydropower, highways, industries, mines etc.) are employed.

BOOKS RECOMMENDED:

1. Prasad Modak and Asit K. Biswas. 1999. Conducting Environmental Impact Assessment for Developing Countries.
2. Canter, L. W. 1996. Environmental Impact Assessment. 2nd Edition.
3. Awan, N.M and M. Latif. 1999. Environmental Assessment of Irrigation and Drainage Projects. Volume-1 &2.

THEORY:

Introduction: Importance, scope and components of farm irrigation system. Irrigation Requirements: Potential evapotranspiration, Crop Coefficient, Crop water requirements, effective rainfall, net and gross irrigation requirements. Water Source: Different water sources for irrigation, water quality and quantity assessment.

Design: Data requirements for design of farm irrigation system, Farm resources and cropping pattern, assessment of water need of the farm, hydraulic of surface irrigation tertiary unit system design, water distribution system design, layout of field ditches, disposal of excess water. Flow measurement: Different method for flow measurements i.e weir, v-notch, orifice, current meter, flumes and float method etc. Evaluation of irrigation System: Soil moisture deficit before irrigation, assessment of depth of water application and need at field and farm level, on-farm application efficiency.

BOOKS RECOMMENDED:

1. Larry G. J., 1988. Principles of farm irrigation system design, John Wiley and Sons, U.S.A.
2. ASAE, 1983. Design and operation of farm irrigation system, Michigan, U.S.A.

WRM-707**WASTE WATER TREATMENT****3(2,2)****THEORY:**

Introduction: Overview of wastewater problem in Pakistan, sanitation and reuse of domestic and industrial water, safe reuse of wastewater, review of techniques for wastewater treatment, national environmental quality guidelines. Municipal Waste Treatment: A description of the stages of treatment of sewage: Preliminary screening and grit removal; primary settlement; secondary oxidation processes - filters, activated sludge, oxidation ditches; small package plant; secondary settlement; tertiary treatment options; sludge treatment and disposal; development of a high efficiency methanogenic digestion process to recover energy from waste, system engineering problems in raw materials recovery from domestic refuse, and leaching of pollutants from sanitary landfills. Industrial Waste Treatment: Developing processes for treating and recycling industrial wastes; introduction of wastewater treatment and recycling systems in petroleum refineries and paper mills, as well as treating metal finishing waste streams to make them treatable in municipal plants. Agricultural Waste Treatment: Investigation of animal wastes derived from dairy cows, cattle, and poultry; Remediation of contaminated soils and groundwater. Bio-remediation and bioventing methods and reclamation of saturated and unsaturated zones. Monitoring of Wastewater Reclamation and Reuse Systems: Treatment, conveyance, disinfections, operational and seasonal storage, health aspects, agro technical aspects and all other water quality aspects related to these schemes.

PRACTICAL:

Field trips to various industries to gain first-hand knowledge of processes involved in treatment.

BOOKS RECOMMENDED:

1. M. Henze, et al . 1997. Wastewater Treatment: Biological and Chemical Processes
2. Droste, R. 1996. Theory and Practice of Water and Wastewater Treatment
3. Smethurst. 1997. Basic water treatment for application world-wide. 2nd Edition.

THEORY:

Binary arithmetic: Representation of numbers in computer. Errors in arithmetic operations. Errors in computational methods. Complex numbers and their graphical representation. Damoivre's Theorem. The roots of any real or complex number. Functions of a complex variable. Limits and continuity. Statistics and probability: Classification, tabulation, classes, graphical representation, histograms, frequency polygons, frequency curves and their types. Means: A.M., G.M., H.M., and their properties; Weighted mean median, quartiles, mode and their relations; Merits and demerits of averages. Range, moments, skew ness, quartile deviation, mean deviation, standard deviation, variance and its coefficients, kurtosis. Goodness of fit: Fitting a straight line, parabola, and circle. Scatter diagram, linear regression and correlation. Definitions, sample space, events, Laws of probability, conditional probability; Dependent and independent events. Introduction, distribution function, discrete random variable and its probability distribution; Continuous random variable and its probability density function; Mathematical expectation of a random variable; Moment generating functions. Binomial Poisson, uniform, exponential and normal distribution functions and its approximation to Poisson distribution.

BOOKS RECOMMENDED:

1. Yousaf, S.M. and M. Amin.1985. Calculus with Analytical Geometry
2. Thomes, B. G. 1987. Calculus & Analytical Geometry.
3. Sharma, G.S., K.L.Auhuja and I.J.S. Sarna.1988. Advanced Mathematics for Engineers and Scientists

THEORY:

Introduction: Importance of statistics in water resources and environmental management, basic statistics; probability, distributions, hypothesis testing, frequency analysis of extreme events, regression analyses and time series. Basic statistics: Population versus sample, random sampling data, stratified sampling data, estimators and estimate, hypothesis testing, discrete and continuous variable, frequent, cumulative frequencies, cumulative relative frequency, histogram mean, median, mode, variance, sample variance, standard deviation; data reduction, the histogram, mean and variance. Probability: Basic concept of probability, conditional probability, movement and their sample estimators, distribution of probability, probability mass function, probability distribution function, probability distribution for extreme events in hydrology, the Gumbel distribution, Pearson type-3 distribution and log Pearson distribution, goodness of fit test, confidence intervals, mean and variance of probability distribution, statistical inference. Regression analysis: Application of regression techniques, linear regression analysis, multiple regression analysis, development of regression models, analysis of covariance; time series analysis,

single time series analysis, multiple time series analysis, independent series, moving average. Principles of Experimental Design: Completely randomized design (CRD), randomized, complete block design, Latin Square design, Double blocking, Factorial experiments, two factor experiment, three factor experiments, split block design.

PRACTICAL:

Data collection and analysis, probability of rainfall and flood, analysis of rainfall return period, Use of statistical package (SAS, SPSS and Minitap etc), Analysis of variances, statistical models

BOOKS RECOMMENDED:

1. Murray, A.D, Statistical modeling in GLIM, Multi-line books.
2. Anderson, V.L. and R.A. McLean, 1989. Design of experiments a Realistic Approach, Marcel ekker, Inc New York and Basel.
3. Dixon, W.J. 1969. Introduction to statistical analysis, 3rd edition, McGraw-Hill, New York.

WRM-710

HYDRO-METEOROLOGY

3(3,2)

THEORY:

Climate: Measurement of climatic factors, air masses and fronts, synoptic maps, cyclones and anticyclones, Monsoons. Hydro meteorological network: planning and design. Precipitation measurement. Accuracy of measurement of hydro meteorological elements. Precipitation analysis. Probable maximum precipitation and probable maximum flood computations. Area-depth-duration analysis. Intensity-duration-frequency analysis. Antecedent precipitation index. Coaxial analysis. Representation and experimental basin studies. Observation program and instruments. Synoptic Meteorology: Division of air pressure, air pressure and wind, general circulation, types of air, from and depressions, weather forecasting. Measurement Instruments: Weather stations, measurements of temperature, humidity, radiation, wind, transpiration, precipitation and air pressure. Climate: Factors and elements, observations, climatic zones and micro climate of Pakistan,

PRACTICAL:

Excursion to different weather station, short training on the interpretation of a weather map, measurements of temperature, transpiration, precipitation, radiation, humidity, wind and air pressure.

BOOKS RECOMMENDED:

1. Smith, L. P. 1975. Methods in Agricultural Meteorology, Development in Atmospheric Science-3, Elsevier.

IRRIGATION AND DRAINAGE SYSTEMS**THEORY:**

Management Concepts: Basic concepts from organization and management sciences, Irrigation & Poverty alleviation. Conceptual Frame Work of Irrigation System Mgt: Policy, Main system, Tertiary units, Irrigation system analysis and water delivery Policy. Performance Evaluation: Different concepts of performance, Productivity, Equity, Stability and Well-being. Domains of irrigation. Organizational Structures: Irrigation Institutions in Pakistan. Formal & Informal Rules. Deficiencies in the present institutional framework. Dominance of informal rules. Drainage and Salinity Management Options: On farm irrigation and drainage practices, Management of dry land saline seeps, project level waterlogging and salinity management options.

PRACTICAL:

Field sampling and monitoring of soil, water, plants; measurements techniques in drainage and salinity management; use of dynamic optimization models in salinity and drainage management.

BOOKS RECOMMENDED:

1. Bandaragoda, D.J. 1992. Institutional Factors Affecting Irrigation Performance in Pakistan. International Irrigation Management Institute. IIMI Country Paper-Pakistan-No.4
2. Chambers, Robert. 1992. Managing Canal Irrigation. Oxford & IBH Publishing Co. Pvt. Ltd.
3. Reader "Organization of WM" developed in Dept. of Water Management, N-W.F.P. Agricultural University Peshawar.
4. Richard A Smith. 1970. Management Structure for irrigation. Journal of Irrigation and Drainage Division. ASCE. Pp 475-487.
5. Ritzema, H.P., 1994, Drainage Principles and Application, ILRI Publication No. 16. 2nd edition, Wageningen, The Netherlands.
6. Abro;, I.P., J.S.P. Yadv, F.I. Masood, 1988. Salt affected soils and their management. FAO soils Bulletin 39, Tome.
7. Reeve, Charles and J. Watt, 1990. Ground water drought, pollution and management by Charles Reeve and Jacqueline watts editors

WRM-712

**APPLICATION AND USE OF COMPUTER
MODELING IN WATER RESOURCES**

3(1,4)

THEORY & PRACTICAL:

Introduction: Learning objectives, course setup, importance of GIS/RS, Introduction to GIS, basic map concepts, spatial relationships, storing geographical data, topology, organizing map information. Database concepts: Designing the database, identifying and defining data layers and attributes, Coordinate registration, Starting the data automation, workspace organization in the computer. Data capture: key terms, digitizing, steps used to capture data by digitizing, Digitizing maps in ARC/INFO, coverage creation. Making spatial data usable: Steps for making spatial data usable, constructing topology, digitizing errors, correcting spatial data. Attribute data: Steps for getting attribute data into ARC/INFO, creation of tabular data files, storing descriptive information, linking attributes to geographic features. Management of the database: Coordinate system for multi coverage database, joining adjacent maps, database management. Presentation of results: definition of a map, using symbols, steps for creating maps, using ARC/INFO to create maps, Report design and generation, creating map for display.

BOOKS RECOMMENDED:

1. ESRI, (1990), Understanding GIS: The ARC/INFO Method.

WRM-713

INTEGRATED WATERSHED MANAGEMENT

4(3,2)

THEORY:

Introduction: Importance and role of Integrated Watershed Management (IWM), Issues and Constraints in IWM, Socio-technical approaches for development, Sustainable Integrated Watershed Management. Concepts and Approaches to Participatory I W M: Overview of recent approaches, New developments in socio-economic concepts, Small vs big Watershed development and biodiversity, Conflict Management. Water harvesting Practices: Micro-catchment development in Pakistan & Worldwide. Catchment area ratio and grid spacing. Land development techniques. Runoff Estimation, 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, Antitranspirants. Floodwater Harvesting: Runoff agriculture, Flood Water Harvesting within streambed, Flood irrigation Diversion, Diversion Structures, Channels and Field Development, Earthen ponds and Small dams. Agroforestry & Water Management: Fruit and forest trees and crops on sloping lands and water management. Social Organization: Village Organizations for integrated watershed management in Pakistan & worldwide. New Methods, Skills & Tools: Three 's' technologies for Watershed Management, Global Positioning System(GPS), Geographic

Information System (GIS), and Remote Sensing(RS). Planning, Monitoring and Evaluation: Key Elements, Principles of Participatory Planning, Monitoring and Evaluation, Participatory Rural Appraisal tools and techniques.

PRACTICAL:

Field study trips to Tarbela Watershed area and other locations and writing reports

BOOKS RECOMMENDED:

1. Bhatta, B.R., Chalise, S.R., Myint,A.K., and Sharma, P.N. 1999. Recent Concepts, Knowledge, Practices & New skills in PIWM. Dept. of Soil Conservation and Watershed Management, Nepal.
2. Reij, C., Mulder, P & Begemanm, L.,1988. Water harvesting techniques for plant production. Washington D.C., World Bank. pp 38-67.
3. Water Harvesting and Spate Irrigation. On Farm Water Management Field Manual, Volume X, 1996. Federal Water Management Cell. Ministry of Food, Agriculture & Livestock, Govt. of Pakistan.
4. Fredrick R Troeh, J.Arthur Hobbs., Roy L. Donahue. 1980. Soil & Water Conservation for Environmental Protection. Chapter 14. Drought Management & Decreasing Runoff Losses.

WRM-714

DESIGN OF DAMS

4(3,2)

THEORY:

Introduction: Needs of Water Reservoirs, Types of dams, Importance of Reservoirs in national and global level. Types of Dams: Classification of dams, according to use, hydraulic design and material use, Physical factors, topography, geology, rock foundation, gravel foundation, clay foundation, spillway, earthquake, legal, economic, esthetic and ecological consideration. Investigations and Planning: Source of supply, runoff estimation, estimation of flood flow, water requirements, reservoirs sites, seepage losses, stability of reservoir sides, sedimentation in reservoirs, foundation of dams, availability of dam building material, subsurface exploration, soil sampling. Design of Dams: General consideration, homogenous dams, zoned dams, diaphragm dams, cutoff excavation, borrow pits, spillway, freeboard, upstream slope protection, settlement, outlet pies, siphon, top soil cover, estimation of earthworks volumes and storages capacities, plan and specifications, design of other common types of dam, concrete dams etc. Construction of Dam: Setting out works, Pre-construction inspection, Construction equipment Dewatering operation, cleaning and stripping the sites, cutoff excavation, foundation, embankment construction, Spillway construction, Continuous Monitoring of Construction of Works, final inspection.

PRACTICAL:

Computation of stream flow into the reservoir, assessment of runoff from a given rainfall in the watershed, assessment of sediment inflow, estimation of seepage losses from earthen dams, design of dams, design of spillway, excursion to Warsak and Terbela dams sites

BOOKS RECOMMENDED:

1. Khushalani, K. B. and M. Khushalni, 1987, Irrigation practices and design of arch, buttress, earth and rockfill dams, volume III, Oxford & IBH Publishing Co, PVT Ltd New Dehli.
2. Nelson, K.D 1991, Design and Construction of small earthen, Scientific Publsiher 5-A, New Pali Road, P.O. Box No. 91, Jodhpur, India
3. Vito A. Vanoni, 1977, Sedimentation Engineering, ASCE manual and Technical report No. 54,
4. Burea of Reclamation 1987, Design of Small Dams, A Water Resources Technical Publication, United States Government Printing Office , Denver, Colorado.

WRM-715 WATER MANAGEMENT COMPUTATIONS 4(2,4)**THEORY AND PRACTICAL:**

Models: Importance of models in water management, types of models, assumption use in model, merits and demerits in models, quantitative models, linear programming, linear algebra, introduction to dynamic programming.

BOOKS RECOMMENDED:

1. McCarl, Bruce A. and T.H. Spreen. Applied Mathematical Programming. Under print
2. Wu, Nesa and R. Coppins. Linear Programming and Extension. New York: McGraw-Hill, 1981.
3. Parikh, A. and David Bailey, Techniques of Economic Analysis with Applications Harvester Wheatsheaf, U.K., 1990.

WRM-716 RESEARCH TRENDS IN WATER RESOURCES 2(2,0)**THEORY:**

Latest research developments and publications in the areas of Water Resources Engineering will be covered in this course. Contents will include a review and discussion on the current national and international research priorities in the field of Water Resources Engineering. The latest research conducted by institutions such, such as International Land Reclamation Institute (ILRI), Department for International Development (DFID) UK, International Waterlogging & Salinity Research Institute (IWASRI), International Water Management Institute (IWMI),

Food and Agriculture Organization (FAO), International Committee on Irrigation and Drainage (ICID), will be used.

WRM-717 RESERVOIR OPERATION AND MANAGEMENT 3(2,2)

THEORY:

Introduction: Reservoirs classification (Storage, flood control retarding and detention reservoirs and distribution reservoirs). Purpose of reservoir operation, Type of hydrological data required for reservoir operation. Major reservoirs of Pakistan and their operational and management rules. Reservoir Operation: Regulation of flood control, Power generation, Irrigation reservoir, Problems of single and multipurpose operation, Reservoir operation rules including policies and procedures. Introduction to reservoir operation using system analysis techniques and operational research applied in reservoir operation. Flood control procedure by reservoir operation. Mass Curve and Demand Curve: Determination of reservoir capacity required for specific yield or demand using mass curve. Demand pattern for various type of reservoirs, Flood routing by graphical inflow, outflow discharge curve method, Trail and error method. Reservoir Sedimentation: Sources of sediment, Factors effecting erosion, Silt load estimate for reservoirs, Mechanism of sediment distribution in reservoirs, Prediction of sediment distribution, Estimation of life of reservoir. Operation and Maintenance of Dams: Maintenance of spillways, outlet pipes, earth embankments and foundation, storage dams, diversion dams, flood detention reservoirs, emergency preparedness plan, dam operating trainer, periodic examination and evaluation, reservoirs problem, silting seepage control, toxic algae, reservoir safety, marine life.

PRACTICAL:

Reservoir operation using simulation methods with help of historic and SYNTHETIC inflows, Computer models for reservoir operation.

BOOKS RECOMMENDED:

1. Guggino,E., Rossi,Giuseppe, Hendricks,D. 1998. Reservoir Operation. Martinus Nijhoff Publishers. The Hauge.
2. Loucks, Stedinger and Haith. 1999. Water Resources System Planing and analysis. Prentice and Hall.

WRM-718

RIVER ENGINEERING

3(3,0)

THEORY:

Historical development, general references properties of river flows. Rigid and moveable boundary hydraulics. Fluvial morphology. Insipient motion gradation and degradation. Flow in alluvial channels. Analysis of alluvial bed forms. Stability of alluvial channels. River regulation & control. Diversion structures. Scour near piers and its control erosion and deposition. Reservoir sedimentation regime concept.

BOOKS RECOMMENDED:

1. Punmia, B. C., L. Pande, B. Delhi. 1979. Irrigation and Water and Power Engineering. Standard Publishers Distributors.
2. Riejn. 1992. Lecture Notes on River Engineering. The Netherlands.
3. Jansen, P.Ph., L. V. Bendegov, J. V. Bery, 1979. Principal of River Engineering

WRM-719

FLOOD ESTIMATION AND CONTROL

3(3,0)

THEORY:

Classification of floods, introduction to flood estimation and design of flood frequency. Flood estimation: peak flow determination, flood determination for ungrouped catchments, flood estimation for gauged watersheds, probable maximum flood, flood hydrograph. Prediction of the runoff hydrograph from a design storm, flood estimation from catchment's characteristics, flood estimation by statistical methods, regional flood frequency analysis, flood hydrograph estimation using SCS method, estimation of flood using routing techniques, choice of estimation techniques. Flood control. Classification of flood, methods of flood control, flood control by reservoirs, retarding, basins, construction of levees, channel improvement, soil conservation measures, combination of flood control measures, flood forecasting and warning, flood control economics. Adjustments: Emergency evacuation and rescheduling, structural adjustment, land use.

BOOKS RECOMMENDED:

Sharma R.K., 1984. Text Book of Irrigation Engineering and Hydrological Structure, Oxford and IBH Pub. Co. New Delhi, India.

THEORY:

Sedimentation: sediment measurements; principles of dynamics of suspended and bed sediment transport in erodible channels; erosion, transportation, and deposition of sediment by flowing water; critical stress; bed, form regimes in alluvial streams; depth, discharge relations for rivers; bed load and suspended load movement; river stability; flow in bends; river training. Comparison of different sediment transport equations: bed load transport, suspended load, and total load transport equations.

PRACTICAL:

Assessment of suspended sediment in canal and flood water, design of soil conservation structures, excursion to different water reservoir, sedimentation problem in canal, water courses and dams

BOOKS RECOMMENDED:

1. Schwab, G. O., D. D. Fangmeier, W. J. Elliot, R. K. Frevert, 1993, "Soil and Water Conservation Engineering", Fourth edition, John Wiley and Sons.
2. Graaff, de, J., 1997, "The price of soil erosion, an economic of soil conservation and watershed development", Distributors Backhuys Publishers, P. O. Box 321 AH Leiden, The Netherlands.
3. German Association for Water Resources and Land Improvement, 1990, "Sediment Transport in open channels calculations procedures for engineering practices"
4. Troeh, F.R., J.A Hobbs, and R. L. Donahue, 1980, "Soil and Water Conservation for Productivity and Environmental protection", Prentice,Hall.
5. Engineering Field Manual, 1990. "United States Department of Agriculture Soil Conservations Services".
6. Vito A. Vanoni, 1977, "Sedimentation Engineering", ASCE manual and Technical report No. 54,

THEORY:

System engineering, concepts, representation, goals, objectives constraints, optimum solution, system models, objective function, constraint equations, feasible and optimum solutions. Systems Analysis approach. An overview of optimization techniques, constrained and unconstrained optimization. Graphical solution to linear models; practical examples to demonstrate graphical methods. Graphical solution to non-linear problems; Maximum output model. Use of Calculus. Linear Programming. Dynamic Programming. Sensitivity Analysis. Application of System techniques to water resources system.

BOOKS RECOMMENDED:

1. McCarl, Bruce A. and T.H. Spreen. Applied Mathematical Programming. Under print
2. Wu, Nesa and R. Coppins. Linear Programming and Extension. New York: McGraw-Hill, 1981.

WRM-722**GROUND WATER EXPLORATION****3(3,0)****THEORY:**

Groundwater exploration: reconnaissance survey, surface investigation methods. Subsurface investigations including test drilling, resistivity logging, radiation logging, temperature logging, velocity measurement and other methods. Well design, construction and development. Deterioration of wells; its causes and remedial measures. Groundwater monitoring: observation network, watertable fluctuation. Selection of sites for the observation network. Installation of observation wells and piezometers. Conjunctive use of surface and groundwater.

BOOKS RECOMMENDED:

1. Mahajan, G. 1995. Ground water survey and investigation. Ashish Publishing House, New Dehli, India.
2. Chow, Ven.Te., David R. Maidment, Lary W. Mays. 1994. Applied hydrology. McGraw Hill International Edition.
3. Mutreja, K. N. 1992. Applied hydrology. Tata McGraw-Hill Publishing Company Limited, New Delhi, India.

WRM-723**GROUND WATER MODELING****3(1,4)****THEORY:**

Review of Fundamental Equations: Continuity equations, steady state flow, time variant flow, idealizations. Finite Difference Formulations: Space discretization, time, explicit and implicit forms boundary conditions, solution techniques, seepage analysis, steady seepage, confined, unconfined, field problems, time variant seepage. Regional Groundwater Flow: Governing equations, data requirements and processing, one and multi-dimensional flow Numerical pumping test analysis. Derivation of a model, standard problems, vertical flow components, delayed yield concepts.

BOOKS RECOMMENDED:

1. Ben, S. D., C.A. Brebbia, D. Quazar. 1991 Computer Methods in Water Resources-II in Groundwater Modelling and Pressure Flow.
2. Groundwater Modelling and introduction with sample programme in Basic development in water science. Amsterdam, Elsevier.1986.
3. James, A. 1993. An Introduction to Water Quality Modeling.

WRM-794	SEMINAR-I (M. Sc.)	1(1,0)
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The students will be required to collect and analyze data on a specific project assigned by the Supervisor and would present a report in the Second Term.

WRM-795	THESIS (M. Sc.)	10(0,20)
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WRM-796	SPECIAL PROBLEM (Ph. D.)	1(1,0)
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WRM-797	SEMINAR-II (Ph. D.) SYNOPSIS	1(1,0)
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WRM-798	DEFENSE SEMINAR-III (Ph. D)	1(1,0)
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WRM-799	DISSERTATION (Ph. D.)	20(0,40)
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RECOMMENDATIONS

1. Efforts were made for preparation of comprehensive degree programme in Bachelor of Engineering specializing in Water Management at NWFP Agricultural University. Similar degree programme should be initiated at other Universities of Pakistan.
2. Library and Laboratory facilities should be strengthened. Funds for purchase of recent books and journals should be provided to the academic research institutions. Equipments and audio-visual aids for effective training of students should be provided.
3. Short refresher courses/workshops pertaining to teaching methods and information technology may be arranged on priority basis for improvement of teaching skills periodically.
4. Curriculum should be updated after every five years.
5. Funds be allocated for collaboration among various institutes/universities.
6. The committee felt seriously about the shortage of faculty for the proper implementation of newly developed curriculum. Therefore, the required staff be provided.

(Prof.Dr. Muhammad Latif)
Convener

(Prof.Dr. Muhammad Jamal Khan)
Secretary