CURRICULUM

MASTER OF ENGINEERING
MANAGEMENT (MEM)

IN

CONSTRUCTION MANAGEMENT

CONSTRUCTION MANAGEMENT COURSE

Compulsory and Common Elective Courses					
Compulsory Courses			**Common Elective Course**		
Course Code	**Course Title**	**Credit Hrs**	**Course Code**	**Course Title**	**Credit Hrs**
EM-501	Organizational Systems	3	EM-511	Total Quality Management	3
EM-502	Accounting and Financial Management	3	EM-512	Project Evaluation and Feasibility Analysis	3
EM-503	Strategic Planning and Decision Making	3	EM-513	Research Methods in Engineering Management	3
EM-504	Project Management Framework and Tools	3			
EM-505	Operations Research	3			
Elective Courses					
CE-544	Quantitative Tools for Engineering Management	3	CE-591	Cost Engineering and Control	3
CE-545	Construction Claim Management	3	CE-592	Decision Making and Risk Management in Construction	3
CE-546	Vulnerability Analysis and Hazard Mitigation	3	CE-593	Construction Operations and Development of Technologies	3
CE-547	Housing for Developing Countries	3	CE-594	Bidding Strategy and the Legal Construction Environment	3
CE-548	Occupational Health and Safety in Construction Project Management	3	CE-595	Technical Entrepreneurship and the Management and Marketing of Construction Services	3
CE-549	Value Engineering in Construction	3	CE-596	Public Infrastructure Management	3
CE-550	Construction Productivity Management	3	CE-597	Real Estate Management	3
CE-587	Human Resource Management in Construction Industry	3	CE-598	Construction Failure Analysis	3
CE-588	Leadership in Construction Management	3	EQ-532	Fire Safety and Management	3
CE-589	Supply Chain Management in Construction	3	CE-5022	Forensic Engineering	3
CE-590	Advanced Topics in Project Management	3	CE-5002	Thesis	6
CE-5023	Building Information Modelling (BIM) for Construction Industry	3			

COMPULSORY COURSES

EM-501 Organizational Systems 3 Credit Hours

Definitions of management; Evolution of management thought, classical, quantitative and behavioural schools; Interactions between organizations and their environments. The planning process; Strategic and tactical planning, developing planning premises, nature of managerial decision making, quantitative aids, management by objectives. Organizational structures; Behaviour of the individual, work group, and organization; Coordination and spans of control, the informal organization; authority delegation and decentralization, groups and committees, managing organizational change and conflict. Motivation, performance and satisfaction; Building a high-performance team; Leadership, interpersonal and organizational communication, staffing and personal function. The control process; Budgetery and non-budgetery methods of control; Team performance measurement and improvement strategies. Use of management information systems.

EM-502 Accounting and Financial Management 3 Credit Hours

Foundations of finance with applications in corporate finance and investment management. Major financial decisions made by corporate managers and investors with focus on process valuation. Criteria for investment decisions, valuation of financial assets and liabilities, relationships between risks and return, market efficiency, and the valuation of derivative securities. Major corporate financial instruments including debt, equity and convertible securities. Analysis and projection of financial statements, cost elements in pricing, cost control and design of accounting systems.

EM-503 Strategic Planning and Decision Making 3 Credit Hours

Critical issues in shaping the competitive strategy for engineering-driven companies in a turbulent business environment; Corporate mission; Key Result Areas and situational analysis including strengths, weaknesses, opportunities and threats; Identifying planning assumptions, critical issues, setting objectives, formulating strategy. Managing technology as a strategic resource of the firm; Understanding of the process, roles and rewards of technological innovation; Integrating the strategic relationship of technology with strategic planning, marketing, finance, engineering and manufacturing; Government, societal and international issues; Issues pertaining to cultural diversity and ethical concerns. Subjective, judgmental and expert decisions; Conflict resolution in strategic decisions involving technological alternatives; Hierarchical decision modeling; Individual and aggregate decisions; Decision discrepancies and evaluation of group disagreements.

EM-504 Project Management Framework and Tools 3 Credit Hours

Role of projects in organization's competitive strategy; Standard methodologies for managing projects; Project life cycle; Design-implementation interface; Estimating: preliminary

and detailed; Contractual risk allocation; Scheduling: PBS; WBS; Integration of scope, time, resource and cost dimensions of a project; Evaluation of labor, material, equipment, and subcontract resources; Scheduling techniques including CPM/ PERT, GERT, critical chain; Solving real-world project schedules; Monte Carlo simulation; Cost budgeting; Cost baseline; Cash flow analysis; Earned value analysis; Cost control; Proposal presentation; Application of software for project management (MS Project, P3).

EM-505 Operations Research 3 Credit Hours

Deterministic modeling: Linear programming; The simplex method; Multiple objective linear optimization; Duality and sensitivity analysis; Post optimality analysis from the viewpoint of technology management; Transportation, transshipment, and assignment problems; Problem. formulation; Goal programming; Network analysis; Dynamic programming; Integer programming and nonlinear programming. Probabilistic modeling: Markov chains; Queuing theory and applications; Inventory theory; Forecasting; Design analysis and simulation; Pareto optimality and tradeoff curves.

COMMON ELECTIVE COURSES

EM-511 Total Quality Management 3 Credit Hours

Critical principles and procedures of quality management in a competitive global environment; contemporary definitions of quality; construction quality; Product quality; Process quality; Quality economics; Quality philosophies; Planning, organizing and controlling for quality; Human resource strategies; QA and QC tools.

EM-512 Project Evaluation and Feasibility Analysis 3 Credit Hours

Evaluation of engineering projects from the engineering management perspective; Techniques for capital investment for decision-making; Time value of money and the concept of equivalence; Present worth, annual and rate of return analysis; Multiple alternatives; Replacement criteria; Tax considerations; Breakeven sensitivity analysis; Project evaluations under uncertainty; Risk sharing; Capital budgeting; Cost of capital depreciation; Multicriteria decisions. Project feasibility analysis; Organizational impacts; Societal impacts; Environmental impacts.

EM-513 Research Methods in Engineering Management 3 Credit Hours

Research methods in engineering and technology management; Statistical techniques including proper selection; Use and interpretation of parametric and non-parametric tests along with factor and discriminate analysis; Design of experiments and model misspecification; Simulation in engineering and management research and practice.

ELECTIVE COURSES

CE-544 Quantitative Tools for Engineering Management 3 Credit Hours

Descriptive measures and review of probability concepts. Demand estimation and Time Series Forecasting and Index number. Linear Programming for decision making, Optimization techniques and management tools, Decision making under risk, Multivariate and constrained Optimization, Economics Order Quantity (EOQ) model for inventory, Networks, Hypothesis testing for decisions, Analysis of Variance (ANOVA) techniques, Multiple regression and correlation analysis.

(Course to be supplemented by Case Studies)

CE-545 Construction Claim Management 3 Credit Hours

Construction claims administration and avoidance. Covers the importance of construction contract errors, unforeseen and changed conditions, disruptions, acceleration, termination, and proving of claims; Dispute Resolution in Pakistan - Case study and analysis of reported appellate decisions on common construction law issues; licensing; bid disputes; contract issues; construction lien law; surety problems; unresolved claims. Construction related documentation requirements for avoidance of litigation before, during, and after completion of construction projects; dispute resolution processes for construction operations.

CE-546 Vulnerability Analysis and Hazard Mitigation 3 Credit Hours

Assessment of risk and potential for damage to a community or facility from the impact of natural or anthropogenic hazards. Physical and construction related issues. Reducing potential damage to the built environment from natural hazards, including hurricanes, floods, earthquakes, explosions. Benefit-cost analysis. Regulatory problems.

CE-547 Housing for Developing Countries 3 Credit Hours

Problems faced by developing countries in housing their population. Political, economic, social, and technical considerations in decision process. Recognition and definition of those factors which affect the planning, financing, and construction of housing projects. The operations and responsibilities of a multidisciplinary team dealing with decision process; housing delivery system including how the housing industry operates, various technologies prevalent in housing construction, and constraints to housing; Future assessment and examination of problems and forces that will shape opportunities.

CE-548 Occupational Health and Safety in Construction Project Management 3 Credit Hours

Introduce the graduate student in Construction Management to the important elements essential in managing the health and safety function of a construction company. Principles of

safety engineering applied to construction industry, job safety analysis, reduction of accident rates, protective equipment, safety rules and regulations; Health and Environmental Management Issues in construction; Health hazards; Environmental hazards; OSHA and Construction Health and Safety; Discussion of the common hazardous materials and waste regulations found in construction activities.

CE-549 Value Engineering in Construction 3 Credit Hours

The Value Concept; Developments in Value Thinking; Relationship of costs to time and life cycle of construction projects, and methods to improve the economic value of construction projects; Function Analysis; Teams, Team Dynamics and Facilitation; Current Study Styles and the Value Process; Value Framework; Value Engineering Job Plan; Project Value Chain; Client Value Systems; Application of Value Engineering Job Plan to Construction Projects; Professionalism and Ethics within Value Engineering; Value Engineering Organization in the Construction Industry; Future of Value Engineering.

CE-550 Construction Productivity Management 3 Credit Hours

Construction Productivity: Definition and Importance; Failing Productivity Diagnosis; Method Improvement in Construction Operations; Productivity Improvement by Work Measurement; Productivity Analysis using Tested Scientific Models and Methods; Production Planning and Control; Construction Workforce Motivation; Computer Applications in Improving Productivity; Managing Construction Projects for Improved Productivity.

CE-587 Human Resource Management in Construction Industry 3 Credit Hours

The challenges of managing people in construction industry, Modern organizational and management theories, strategic concepts and operational implications of human resource management in construction industry strategic approaches to managing human resource in the construction industry The mechanics of human resource in construction resourcing development and rewards approaches to managing employee relations Employee participation involvement and empowerment in construction industry Workforce diversity equal opportunities and work life balance in construction industry Employee healt safety and welfare in construction industry strategic human resource development in construction industry issues and trends of human resource management in 21st century strategic human resource management as a route to improved business performance in construction industry Training motivation and performance of HR in construction projects Training Needs Assessment, Effective Training Provision, Evaluating Training Managers as Trainers and Trainees, Workforce Literacy improving learning inhibitors, performance Appraisal best practices of project HR planning in the construction industry best practices of project HR development in the construction industry Assessing the impacts on performance improvement of construction projects with improved HR planning and development.

CE-588 Leadership in Construction Management 3 Credit Hours

What is leadership introduction to construction leadership Qualities of an effective construction

leader leadership styles in modern construction project management building and Maintaining a Following leadership vs. Management leadership and change in construction projects history of leadership research and theory leadership potential Profile of a construction leader Myths and Realities of construction leadership Teambuilding and Teamwork Developing firm foundation to become a construction leader respect trust influence by-in Ethics stress management improving personal productivity social network building motivational drivers of construction leaders and their followers vision planning leading by example intuition momentum elements of winning developing construction leaders leading from the top empowerment legacy leading the close-out process of a construction project learning from lessons learned leadership challenges in changing world taking up the role of leadership the transition process innovation culture for sustainable development motivating people in construction organizing people and resources in construction transforming people leading people with authority leading people without authority leading geeks developing a sustainable construction work environment to gain organizational objectives overcoming

CE-589 Supply Chain Management in Construction 3 Credit Hours

Logistics and supply chain management basics logistics and supply chain management in construction factory and construction physics variability and buffering in production management of inventory in the supply chain re-engineering of supply chain relational contracting and other contractual issues in the construction supply chain assuring the quality of procurement system for construction contractors strategic SCM Customer focus in SCM analytical approaches to deal with logistics issues in construction reliable commitment model buffer management and negotiation with third parties information technology in construction logistics and supply chain management construction logistics simulation Aligning supply chain with business strategy high performance supply chain organization performance measurement system for managing supply chain best practices and benchmarking for supply chain green supply chain sustainable logistic and supply chain management.

CE-590 Advanced Topics in Project Management 3 Credit Hours

Enterprise project management; Project Management Office; PM maturity models; PM integrated advanced techniques; PM Monitoring, Evaluation, Reporting and Control Framework; Application of software for project monitoring, evaluation and control (MS Project/ P3); Project Audit and Closure; Design integration management in construction; Communication and Conflict Management in Construction; Professional Responsibility and Ethics; Learning Curves; Leadership; Managing Project Teams; Partnering; Negotiating; Managing Customer Relations; International Construction Project Management: Introduction to procurement, financing and management of international construction projects with emphasis on international economics, contracts, trade agreements and specifications; Maintenance Management of construction projects; Construction/ Project Management Proposal Presentation.

CE-591 Cost Engineering and Control 3 Credit Hours

Introduction to Cost Engineering; Cost Estimating: Estimate Accuracy; Estimate Approaches/ Classes; Estimating Methods; Computerized Estimating; Labor Productivity

Analysis; Equipment Unit Cost Estimation; Indirect Costs; Data Collection and Management; Activity Unit Price Estimation based on Field Data; Estimate Coding and Documentations; Predicting Future Escalation; Contingency; Application of computer software to rigorous exercises in construction estimating. Cost Control: Introduction to Cost Control; Role of Cost Control Engineer; Cost Control during Various Project Phases; Project Changes; Subcontract Development, Administration and Control; Cost Control during Construction; Monthly Cost Report and Cost Control Meetings; Computer Applications; The Cost of Cost Control; Control of Bulk Materials; Case Studies.

CE-592	Decision Making and Risk Management in Construction	3 Credit Hours

Sources of hazards; Definition of risk; System analysis; Functional modeling and analysis techniques; Techniques of analysis of engineering systems for risk management decisions involving trade-offs (technical, humans, environmental aspects); Risk assessment, communication and management; Elements of decision analysis; Probabilistic risk analysis (fault trees, event trees); Analytical Hierarchy Process; EMV and EUV Criteria; Inventory Modeling; Monte Carlo Simulation; Risk acceptance; Consequence assessment; Risk benefit assessment; Economic analysis of failure consequences (issues of human safety and long-term economic discounting); Uncertainty sources and types; Uncertainty modeling; Human factors engineering; Quantitative and qualitative risk analyses and management strategies employed in proactive, reactive, and interactive modes; Emphasis on risk management issues in public and private sector.

CE 593	Construction Operations and Development of Technologies	3 Credit Hours

Construction methods and practice; Design and construction technologies; Construction operations management: Integrated approach to planning, scheduling, modeling, analysis and design of construction processes and operations; Use of simulation models and other analytical tools; Constructability; Subcontractor and supplier management; Equipment selection; Material selection, procurement and control; Construction facilities and site development; Lean construction mechanisms for identifying and eliminating wastage and unnecessary cost by examining the construction process with a TQM framework. Artificial Intelligence Applications in Construction Management. A study of the concepts, techniques, and applications of AI technology in the construction management domain; Study of advanced field techniques and emerging uses worldwide. Information flow and creativity are highlighted as crucial elements which stimulate new developments. This course prepares the students to understand and deal with concepts of change.

CE-594	Bidding Strategy and the Legal Construction Environment	3 Credit Hours

Contract types and their implications on estimation and bidding procedures; general office operations, and bidding procedures; Bid Package Preparation; Tender Negotiations; Development of Working Methodologies. Legal and business aspects of engineering contracts and specifications in the construction industry. Legal principles as framework of interaction of project stakeholders; Contracts for civil engineering services; Contract risk allocation and

reciprocal liabilities; Issues of contract formation, breach, and remedy; Analysis, study of precedents, and application of contract clauses, including changes, changed conditions, termination, disputes, payments, risk and insurance, inspection, liquidated damages, and technical requirements.

CE-595 Technical Entrepreneurship and the Management and Marketing of Construction Services 3 Credit Hours

Managerial, financial, legal, ethical and organizational aspects of starting and growing a construction organization; Setting up a virtual company and carrying it through the entrepreneurship process; Marketing aspects of entrepreneurship including market research (Guest lectures from practicing entrepreneurs, financiers and professionals associated with the entrepreneurship process should play a key role in the course). Management of a construction company: company organization, incorporation structures, policies and procedures, finance, accounting, information modeling, bidding strategies, and operation; Human effectiveness in marketing construction services in the public and private sectors.

CE-596 Public Infrastructure Management 3 Credit Hours

Complexities, expanding pressures and demands on infrastructure management; Issues, identification of indigenous needs and managing provisions of required infrastructure facilities; Maintaining public infrastructure inventories; Assets management models. Methods and integrative approaches for balanced infrastructure management policies and practices; Roles of civic agencies/ essential services organizations; Disaster mitigation and management scenarios. Strategies for interaction between government and informal sectors; Infrastructure sustainability under economic constraints; Procuring funding for public infrastructure projects through non-conventional alternatives; Contemporary tools and instruments such as GIS/ LIS in public infrastructure management; Global trends and case studies.

CE-597 Real Estate Management 3 Credit Hours

Real Estate fundamentals; Real Estate Finance; Urban economic development and Real Estate market analysis; Real Estate development; Housing Economics and Finance; Real Estate investment decisions; Legal issues in Real Estate.

CE 598 Construction Failure Analysis 3 Credit Hours

Develop an understanding of the integration process of technical, human, capital, social and institutional aspects that drive the life cycle of a construction project. Study of failures to provide a vehicle to find ways for the improvement of planning, design and construction of facilities; Investigation of failure including technical analysis and also a comprehensive analysis of the organizational, contractual and regulatory aspects of the process that lead to the failure. (This course should use case studies to illustrate different types of failure in the planning, design, construction and operation of constructed facilities).

EQ-532	Fire Safety and Management	3 Credit Hours

. Fire safety concepts; design fires; flame spread, modelling of flame spread and fire growth; external fire spread and heat radiation; smoke movement; buoyancy; principles of smoke hazard management; smoke spread; smoke hazard management subsystems; fire safety measures; fire safety system design principles, occupant evacuation; fire department response; qualitative and quantitative risk assessment; fire safety risk management; logic trees

CE-5022	Forensic Engineering	3 Credit Hours

Introduction to Forensic Engineering; Competencies and Qualifications of Forensic Engineers: qualifications, attributes competencies, technical skills, legal knowledge, detective skills, communication skills, personality characteristics etc. The Standard of Care: expert testimony, methods, validity, reliability, Delphi process of expert consensus; Civil Engineering Investigations: activities in investigation, site investigation, sampling and collection of evidence, preliminary findings, equipment and its selection, recording observations, photography, sample removal, eyewitness account, field tests, document collection and review, theoretical analysis, laboratory tests and investigation, office investigations determination of procedural responsibilities, reports; Ethics of Forensic Engineering: code of ethics, solicitation of work, contract process, testimony ethics, damage caused by unethical conduct, ethical standards for publication, interaction with media; The Legal Forum: role of forensic engineer as a witness in mediation and litigation, admissibility of testimony by forensic engineers, rules of evidence and testimony, testimony in courts and at deposition (preparation, demeanor, speech, direct examination, cross examination etc.), codes and guidelines (local and international) for professionals engaged as experts; The Business of Forensic Engineering: readiness, marketing, decisions, liability, insurance individual and group practice; National and International Case Studies.

CE 5023	Building Information Modelling (BIM) for Construction Industry	3 Credit Hours

BIM Overview; Common BIM Terminologies; BIM as a Communication and Collaboration Tool; BIM Implementation Needs, Challenges and Guidelines for various Stakeholders in Construction Industry; Discussion of BIM Application on Project Life Cycle; BIM Maturity Levels; Develop understanding of how BIM models are applicable to: Reduction of Design Errors, Clash Detection, Quantity Takeoff and Cost Estimation, Construction Analysis and Planning, Energy Analysis, Construction Management, Facilities Management and other aspects of Construction Project Management; Application of nD BIM Technology on a Real Time Project of Challenging Scope; Performing Walkthroughs/ Flythroughs/ Animation, Presentation/ Rendering; Overview of BIM application in allied areas of Construction Industry (such as MEP). Following software may be used; Revit, Tekla, Navisworks, CostX, Primavera, Microsoft Project, Lumion, EnergyPlus etc.

CURRICULUM

MASTER OF ENGINEERING MANAGEMENT (MEM)

IN

WATER RESOURCES MANAGEMENT

Water Resources Management Courses

Compulsory and Common Elective Courses					
Compulsory Courses			**Common Elective Course**		
Course Code	**Course Title**	**Credit Hrs**	**Course Code**	**Course Title**	**Credit Hrs**
EM-501	Organizational Systems	3	EM-511	Total Quality Management	3
EM-502	Accounting and Financial Management	3	EM-512	Project Evaluation and Feasibility Analysis	3
EM-503	Strategic Planning and Decision Making	3	EM-513	Research Methods in Engineering Management	3
EM-504	Project Management Framework and Tools	3			
EM-505	Operations Research	3			
Elective Courses					
CE-556	Resources Planning and Management	3	CE-577	Irrigation System Design and Management	3
CE-557	Legal & Financial Aspects of Water Resources	3	CE-578	Groundwater Resource Management *(Prerequisite EM-505 Operations Research)*	3
CE-558	Sustainable Water Resources Management	3	CE-579	Water Quality Management	3
CE-559	Remote Sensing In Water Resources	3	CE-5022	Forensic Engineering	3
CE-560	Reservoir Operations	3	CE-5002	Thesis	6
CE-576	Water Services Management	3			

COMPULSORY COURSES

EM-501 Organizational Systems — 3 Credit Hours

Definitions of management; Evolution of management thought, classical, quantitative and behavioural schools; Interactions between organizations and their environments. The planning process; Strategic and tactical planning, developing planning premises, nature of managerial decision making, quantitative aids, management by objectives. Organizational structures; Behaviour of the individual, work group, and organization; Coordination and spans of control, the informal organization; authority delegation and decentralization, groups and committees, managing organizational change and conflict. Motivation, performance and satisfaction; Building a high-performance team; Leadership, interpersonal and organizational communication, staffing and personal function. The control process; Budgetery and non-budgetery methods of control; Team performance measurement and improvement strategies. Use of management information systems.

EM-502 Accounting and Financial Management — 3 Credit Hours

Foundations of finance with applications in corporate finance and investment management. Major financial decisions made by corporate managers and investors with focus on process valuation. Criteria for investment decisions, valuation of financial assets and liabilities, relationships between risks and return, market efficiency, and the valuation of derivative securities. Major corporate financial instruments including debt, equity and convertible securities. Analysis and projection of financial statements, cost elements in pricing, cost control and design of accounting systems.

EM-503 Strategic Planning and Decision Making — 3 Credit Hours

Critical issues in shaping the competitive strategy for engineering-driven companies in a turbulent business environment; Corporate mission; Key Result Areas and situational analysis including strengths, weaknesses, opportunities and threats; Identifying planning assumptions, critical issues, setting objectives, formulating strategy. Managing technology as a strategic resource of the firm; Understanding of the process, roles and rewards of technological innovation; Integrating the strategic relationship of technology with strategic planning, marketing, finance, engineering and manufacturing; Government, societal and international issues; Issues pertaining to cultural diversity and ethical concerns. Subjective, judgmental and expert decisions; Conflict resolution in strategic decisions involving technological alternatives; Hierarchical decision modeling; Individual and aggregate decisions; Decision discrepancies and evaluation of group disagreements.

EM-504 Project Management Framework and Tools — 3 Credit Hours

Role of projects in organization's competitive strategy; Standard methodologies for managing projects; Project life cycle; Design-implementation interface; Estimating: preliminary and detailed; Contractual risk allocation; Scheduling: PBS; WBS; Integration of scope, time,

resource and cost dimensions of a project; Evaluation of labor, material, equipment, and subcontract resources; Scheduling techniques including CPM/ PERT, GERT, critical chain; Solving real-world project schedules; Monte Carlo simulation; Cost budgeting; Cost baseline; Cash flow analysis; Earned value analysis; Cost control; Proposal presentation; Application of software for project management (MS Project, P3).

EM-505 Operations Research 3 Credit Hours

Deterministic modeling: Linear programming; The simplex method; Multiple objective linear optimization; Duality and sensitivity analysis; Post optimality analysis from the viewpoint of technology management; Transportation, transshipment, and assignment problems; Problem. formulation; Goal programming; Network analysis; Dynamic programming; Integer programming and nonlinear programming. Probabilistic modeling: Markov chains; Queuing theory and applications; Inventory theory; Forecasting; Design analysis and simulation; Pareto optimality and tradeoff curves.

COMMON ELECTIVE COURSES

EM-511 Total Quality Management 3 Credit Hours

Critical principles and procedures of quality management in a competitive global environment; contemporary definitions of quality; construction quality; Product quality; Process quality; Quality economics; Quality philosophies; Planning, organizing and controlling for quality; Human resource strategies; QA and QC tools.

EM-512 Project Evaluation and Feasibility Analysis 3 Credit Hours

Evaluation of engineering projects from the engineering management perspective; Techniques for capital investment for decision-making; Time value of money and the concept of equivalence; Present worth, annual and rate of return analysis; Multiple alternatives; Replacement criteria; Tax considerations; Breakeven sensitivity analysis; Project evaluations under uncertainty; Risk sharing; Capital budgeting; Cost of capital depreciation; Multicriteria decisions. Project feasibility analysis; Organizational impacts; Societal impacts; Environmental impacts.

EM-513 Research Methods in Engineering Management 3 Credit Hours

Research methods in engineering and technology management; Statistical techniques including proper selection; Use and interpretation of parametric and non-parametric tests along with factor and discriminate analysis; Design of experiments and model misspecification; Simulation in engineering and management research and practice.

ELECTIVE COURSES

CE-556 Resources Planning and Management 3 Credit Hours

regional and international levels, Investigation data and analysis, Demand projection, Water productivity parasites and constraints, Land-Water-Human resources interaction, Plan formulation, evaluation and approval, Comprehensive regional planning, Stakeholder involvement in water resources planning, Social and environmental impact assessment, Institutional arrangements for planning and implementation, Engineering economy in water resources planning, Introduction to surface water / groundwater / conjunctive water management.

CE-557 Legal & Financial Aspects of Water Resources 3 Credit Hours

Sources of Water, Uses of Water, General concepts of water governance, International Laws (riparian and prior appropriation doctrines), Legal schemes for securing and allocating water rights in surface water and groundwater for private and public uses in Pakistan, Water Treatise and Accords (Indus Waters Treaty, Water Apportionment Accord, similar case studies), Institutional Framework, Groundwater management regimes, Issues and national water sector strategy, Evolving role of science, economics, and policy in water allocation law, Major paradigm shifts in water governance through integrated water resource management. Legislation on harmful effects of water.

CE-558 Sustainable Water Resources Management 3 Credit Hours

Historical perspective of water use and development, Water facts and trends, Introduction to sustainable development and its importance, Related terminologies, SWRM strategies, Sustaining healthy freshwater ecosystems, Hydrologic aspects of water sustainability, Human impacts on hydrologic ecosystem and mitigation, Water resources – agriculture, environment, and society, Flood control management strategies, Economics of water; value of water, water affordability and marketing. Emerging water management issues and resolutions.

CE-559 Remote Sensing In Water Resources 3 Credit Hours

History and scope of remote sensing, Concepts of remote sensing, Photogrammetry, Satellite characteristics, Remote sensing imagery types, Remote sensing satellites, Image resolution, Preprocessing, Image rectification, enhancement and classification, Accuracy assessment, Applications of satellite remote sensing in water resources i.e., for identifying drainage basin networks, for watershed dynamics analysis, flood inundation modeling and mapping, Evaluation of surface and ground water resources, Image processing software exercises, Introduction to Geographical Information Systems (GIS).

CE-560	Reservoir Operations	3 Credit Hours

Introduction on the functions of reservoirs and possible problems, Operation purposes, Storage-yield concepts; flow-duration curve development, mass-curve analysis and sequent- peak analysis; Flood management and reservoir operation; formation and process of floods, Techniques for flood prevention in reservoirs, Relationship between flood management and reservoir operation, Reservoir simulation for flood control, urban water supply, hydropower and multipurpose operation, Automatic reservoir operation system; Sedimentation in reservoirs, Preventative methods for the sedimentation in reservoirs, Impacts of sedimentation on the function of reservoirs, Management for sedimentation in reservoirs and techniques for capacity restoration, Ecological environment in water reservoirs and protection & restoration techniques.

CE-576	Water Services Management	3 Credit Hours

Water Supply and Sanitation Systems; options, standards and developments with sustainable performance and technical reliability. Water Supply Systems; raw water quality (surface and groundwater) and abstraction, pre-treatment and storage, water treatment processes and plants, water transport and distribution, Sanitation Systems; on-site and off-site sanitation systems, ecological sanitation concepts, sewerage and drainage systems wastewater treatment processes and plants, sludge management (treatment, disposal and reuse), Institutional arrangements and management options for providing water services. Finance issues at utility level; financing water organisations and undertaking cost-recovery.

CE-571	Irrigation System Design and Management	3 Credit Hours

Introduction/overview of irrigation and its purpose: horticulture, urban landscaping, agriculture, soilwater- plant relationships, irrigation water requirements, computation of evapotranspiration by various methods, performance evaluation of irrigation systems, surface irrigation system-design principles, Design of basin, border and furrow irrigation, Trickle irrigation and sprinkler irrigation – design and operation, irrigation management, irrigation and drainage interactions, environmental consideration.

CE-578	Groundwater Resource Management *(Prerequisite EM-505 Operations Research)*	3 Credit Hours

Introduction to groundwater resources engineering and management, groundwater resources protection and water supply; Technical aspects as well as the legal, regulatory and policy aspects of groundwater resources management; Development of groundwater resource; simulation/optimisation models for GWM; embedding and response matrix approaches, Conjunctive use of groundwater and surface water and planning of groundwater resources projects.

EM-513	Water Quality Management	3 Credit Hours

Water quality parameters-Indicators, sources, causes and effects; Nature of water systems; Objectives and case studies of water quality management; Water quality monitoring, modeling

and forecasting in water systems; Management practices and methodologies for reuse, recycling and treatment of contaminated water; A system approach to water quality management: Institutional, environmental, and ethical aspects.

CE-5022 Forensic Engineering 3 Credit Hours

Introduction to Forensic Engineering; Competencies and Qualifications of Forensic Engineers: qualifications, attributes competencies, technical skills, legal knowledge, detective skills, communication skills, personality characteristics etc. The Standard of Care: expert testimony, methods, validity, reliability, Delphi process of expert consensus; Civil Engineering Investigations: activities in investigation, site investigation, sampling and collection of evidence, preliminary findings, equipment and its selection, recording observations, photography, sample removal, eyewitness account, field tests, document collection and review, theoretical analysis, laboratory tests and investigation, office investigations determination of procedural responsibilities, reports; Ethics of Forensic Engineering: code of ethics, solicitation of work, contract process, testimony ethics, damage caused by unethical conduct, ethical standards for publication, interaction with media; The Legal Forum: role of forensic engineer as a witness in mediation and litigation, admissibility of testimony by forensic engineers, rules of evidence and testimony, testimony in courts and at deposition (preparation, demeanor, speech, direct examination, cross examination etc.), codes and guidelines (local and international) for professionals engaged as experts; The Business of Forensic Engineering: readiness, marketing, decisions, liability, insurance individual and group practice; National and International Case Studies.