CURRICULUM OF

ENERGY SYSTEMS ENGINEERING

FOR

BS/BSc/BE/ 4-YEARS DEGREE PROGRAM

(Revised 2018)

HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

Prof. Dr. Arshad Ali	Executive Director
Mr. Muhammad Raza Chohan	Director General (Academics)
Dr. Muhammad Idrees	Director (Curriculum)
Mr. Hidayatullah Kasi	Deputy Director (Curriculum)
Mr. Rabeel Bhatti	Assistant Director (Curriculum)

CONTENTS

PREFACE

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

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

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

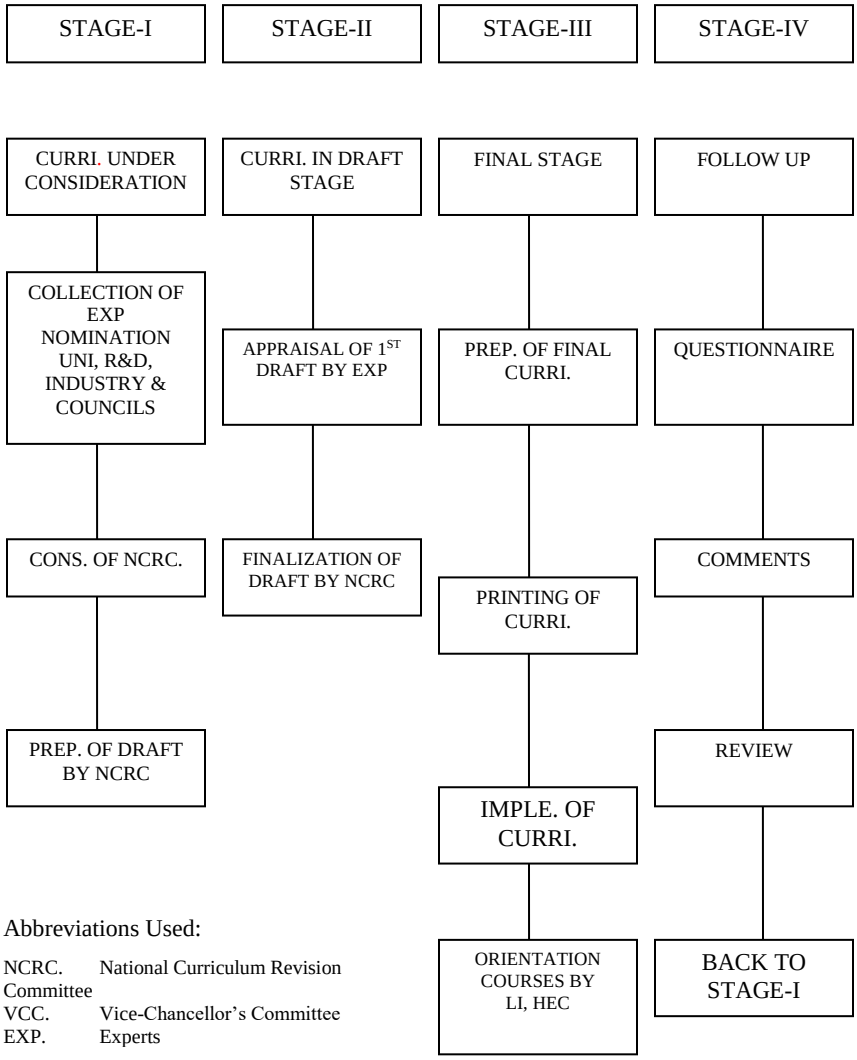
In order to impart quality education which is at par with indigenous needs and international standards, HEC NCRCs have developed unified framework/ templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture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

It is hoped that this curriculum document, prepared by the respective NCRC's, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC

http://hec.gov.pk/english/services/universities/RevisedCurricula/Pages/default.aspx

(Muhammad Raza Chohan)
Director General (Academics)

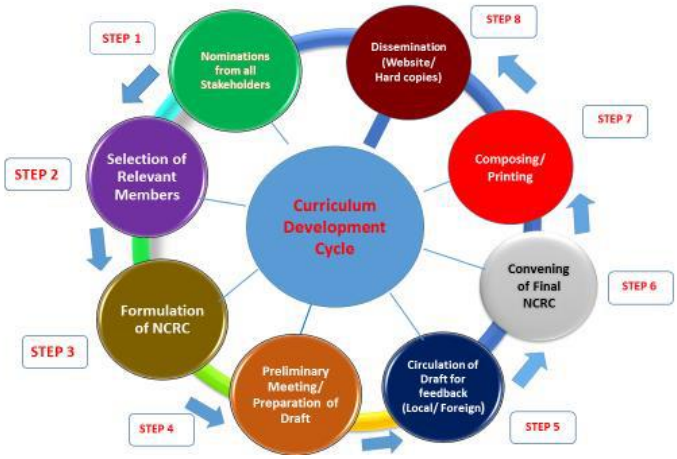
CURRICULUM DEVELOPMENT



Abbreviations Used:

NCRC. National Curriculum Revision Committee
VCC. Vice-Chancellor's Committee
EXP. Experts

CURRICULUM DEVELOPMENT CYCLE



Minutes of National Curriculum Revision Committee (NCRC) Final Meeting of Energy Systems Engineering held from March 12-14, 2018 at HEC Regional Centre, Peshawar

The final meeting of National Curriculum Revision Committee (NCRC) in the discipline of Energy Systems Engineering for Bachelor and Master Degree programmes was held from March 12-14, 2018 (03 days) at HEC, Regional Center, Peshawar. The purpose of the meeting was to finalize the draft curriculum prepared in its preliminary meeting held from December 27-29, 2017 at the Higher Education Commission, Regional Centre, Lahore. Experts from academia, research and development organizations participated in the meeting. Mr. Rabeel Bhatti (Assistant Director, Curriculum, HEC, Pakistan) coordinated the NCRC meeting. The list of the participants is as below:

1.	Prof. Dr. Zahid Mahmood Dean (Research), Abasyn University, Ring Road, Peshawar	**Convener**
2.	Dr. Anjum Munir Associate Professor, Department of Energy System Engineering, University of Agriculture, Faisalabad.	**Secretary**
3.	Prof. Dr. Shahab Khushnood Dean / Professor, Faculty of Mechanical & Aeronautical Engineering, University of Engineering & Technology, Taxila	Member
4.	Dr. Jafar Khan Kasi Chairperson, Department of Renewable Energy, University of Balochistan, Quetta	Member
5.	Prof. Dr. Ahmad Shafi Professor, Department of Mechanical Engineering, The University of Lahore, Lahore.	Member
6.	Dr. Muhammad Asghar Hashmi Professor, Department of Physics, The Islamic University of Bahawalpur, Bahawalpur.	Member
7.	Dr. Faheem Nawaz Associate Professor,	Member

	Department of Environmental Management & Policy, Baluchistan University of Information Technology, Engineering & Management Sciences (BUITEMS), Quetta	
8.	Dr. Mahmood Laghari Chairman / Associate Professor, Department of Energy & Environment, Sindh Agriculture University, Tandojam.	Member
9.	Dr. Muhammad Shakib Associate Professor, Department of Mechanical Engineering, NED University of Engineering & Technology, Karachi.	Member
10.	Dr. Naseem Iqbal Associate Professor, US Pakistan Centre for Advanced Studies in Energy (USPCASE), National University of Science & Tech, Islamabad.	Member
11.	Dr. Muhammad Umair Assistant Professor, Faculty of Agricultural Engineering & Technology, PMAS Arid Agriculture University, Murree Road, Rawalpindi.	Member
12.	Dr. Faheemullah Shaikh Assistant Professor, Department of Electrical Engineering, Mehran University of Engineering & Technology, Jamshoro.	Member
13.	Engr. Dr. Adnan Daud Khan Assistant Professor, Department of Electrical Engineering, Sarhad University of Science & Information Technology, Hayatabad Link, Ring Road, Peshawar.	Member
14.	Dr. Taqi Ahmad Cheema Assistant Professor, Department of Mechanical Engineering, Ghulam Ishaq Khan Institute of Engineering & Technology, Topi.	Member
15.	Dr. Abdullah Mengal, Assistant Professor,	Member

	Department of Mechanical Engineering Baluchistan University of Engineering & Technology, Khuzdar.	
16.	Dr. Umair Sultan Assistant Professor, Department of Energy System Engineering, University of Agriculture, Faisalabad.	Member
17.	Dr. Abdul Ghafoor Lecturer / In-charge, Department of Farm Machinery & Power, University of Agriculture, Faisalabad.	Member
18.	Dr. Muhammad Asim Assistant Professor, Department of Mechanical Engineering University of Engineering & Technology, Lahore.	Member
19.	Dr. Muhammad Sajid Kamran Assistant Professor, Department of Mechanical Engineering University of Engineering & Technology, Lahore.	Member
20.	Rabeel Bhatti Assistant Director (Curriculum) Higher Education Commission Islamabad.	Coordinator

The following members attended the preliminary meeting only and could not attend the final meeting due to other engagements:

1.	Prof. Dr. Aun Abbas Professor, Department of Electrical Engineering, National University of Computer & Emerging Sciences, Lahore.	Member
2.	Prof. Dr. Abdul Fattah Chandio Professor, Quaid-e-Awam University of Engineering, Science & Technology, Larkana Campus, Nawabshah	Member
3.	Dr. Asif Ali Memon Associate Professor **(PEC Nominee)**, Department of Energy & Environment Engineering, Quaid-e-Awam University of Engg, Science & Technology, Nawabshah.	Member
	Dr. Engr. Muhammad Zubair Assistant Professor, US Pakistan Center for Advanced Studies in Energy (USPCASE),	Member

	National University of Science & Technology, Islamabad.	
	Dr. Waseem Amjad, Assistant Professor, Department of Energy Systems Engineering, University of Agriculture, Faisalabad.	Member
4.	Dr. Faheem Akhter Chachar Assistant Professor, Department of Electrical Engineering, Sukkur Institute of Business Administration, Sukkur	Member
5.	Dr. S. Zaheer Abbas Assistant Professor, Department of Chemical Engineering University of Engineering & Technology, Lahore.	Member
6.	Dr. Hassan Abbas Khan Assistant Professor (TTS) Department of Electrical Engineering, Office 9-247A, SSE, Lahore University of Management Sciences, Lahore.	Member

AGENDA FOR NCRC FINAL MEETING IN ENERGY SYSTEM EGINEERING

The agenda for final meeting of NCRC for Energy Systems Engineering is as follow:

1. To finalize the draft curriculum in the discipline of **Energy Systems Engineering** and to bring it at par with international standards.
2. To finalize objectives / learning outcomes, list of contents and assessment criteria (formative & summative) aligned with Bachelor and Master programs.
3. To incorporate/suggest latest reading materials/references (local & international) against each course.
4. To finalize contents keeping in view the uniformity across other disciplines and avoiding overlapping.
5. To make final recommendations for finalization of the discipline, keeping in view the futuristic needs of the society.
6. To finalize the intake criteria for this programme.

Day – 1

Inaugural Session

The meeting started with recitation from the Holy Quran. Mr. Rabeel Bhatti, Assistant Director, Curriculum, Higher Education Commission (HEC), Islamabad welcomed the members on behalf of the Chairman, HEC. He briefed the members of the responsibilities of the Commission to

review/revise the curriculum. He also informed the honorable members regarding the main purpose of revising the curriculum keeping in view the framework/scheme of studies for Bachelor and Master in the discipline of Energy Systems Engineering so that the courses could be made compatible with the International Outcomes Based Education (OBE) standards and be in line with the recent research and development. There was a deliberate discussion among the committee members on the preliminary draft prepared in its last meeting held on December 27-29, 2017, at HEC Centre, Lahore. All those members who have already sent their inputs presented their drafts before the committee for further discussion. All queries and questions were satisfactorily answered by the respective expert members of the Committee.

Technical Sessions-I

In second session, Prof. Dr. Zahid Mahmood, Convener of Committee, briefed the participants that key objective of final NCRC is to devise a curriculum that provides a unified framework (guidelines) to institutions offering degrees under the title of Energy Systems Engineering and also match the global challenges in the field of Energy Systems Engineering.

Technical Sessions-II

Dr. Anjum Munir, Secretary of Committee, presented the preliminary draft of Energy Systems Engineering to the committee and briefed the members about the progress made in the curriculum. The members focused on nomenclatures of various degree programmes, rationale and scope of Energy Systems Engineering, titles of different courses offered during 4 years Bachelor programmes, credit hours, learning outcomes, and assessment criteria of Energy Systems Engineering in different Universities of Pakistan. After detailed discussion and in depth analysis of framework/scheme of studies, Course Learning Outcomes (CLOs) with the inclusion of their taxonomy levels and their respective PLOs and the course contents; the curriculum was finalized for Bachelor of Energy Systems Engineering.

Day-2

Technical Session – III & IV

On second day, courses developed/improved by individual members were presented. Each course was discussed in the whole group and with thorough discussion on course objectives, learning outcomes, contents, teaching methods, assessment and reference books were reviewed, revised and finalized. After thorough deliberation, preliminary draft curriculum of the undergraduate (4-years) degree programme prepared in the preliminary meeting for Energy Systems Engineering was finalized.

Day-3

Technical Session – V (Masters Programme)

On third day, the convener briefed the house about progress made on the previous days. The admission criteria and courses of Master program of Energy Systems Engineering were reviewed by the committee with changes and addition of courses. Furthermore, it was decided that the university may offer the courses keeping in view their expertise and resources with HEC guidelines in consideration. After thorough discussions and considerations the final draft was finalized and approved.

Technical Session VI

In the end, Mr. Rabeel Bhatti thanked the convener, secretary and all members of the Committee for sparing their time and for their contribution to prepare the revised draft of the curriculum. He further stated that their efforts will go a long way in developing workable, useful market oriented and outcome based comprehensive degree programme in "Energy Systems Engineering". The convener of the NCRC also thanked the members for their inputs in revising/updating the curriculum to make it more practical, competitive, efficient and realistic. The committee highly appreciated the efforts made by the officials of HEC Regional Centre, Peshawar for making arrangements to facilitate the committee and their accommodation and recreation tour. The meeting ended with the vote of thanks to HEC and Mr. Rabeel Bhatti and his team from HEC for providing this academic and professional opportunity for national cause.

The meeting ended with vote of thanks to and from the Chair.

RECOMMENDATIONS

The following recommendations are made for implementation of these schemes in the country:

1. The degree nomenclature of Energy Systems Engineering Program will be BS/BSc/BE Energy Systems Engineering.
2. Energy Systems Engineering will be a minimum four year degree program inclusive of mandatory engineering courses of foundation, breadth and depth given in the Energy Systems Engineering curriculum.
3. The Energy Systems Engineering program should be registered as a separate engineering profession with PEC.
4. The PEC is required to facilitate for legislation for induction of Energy Systems Engineering graduates in both relevant public and private sector of Pakistan.
5. The HEC and PEC need to coordinate in the profession of Energy Systems Engineering degree program for internship and

employment generation for the graduates both in relevant public and private sector organizations.

6. The HEC should facilitate the required necessary funding to the universities offering Energy Systems Engineering program as have been facilitating the other Engineering degree programmes.
7. Keeping in view the Energy Systems Engineering programme as a new and need based discipline in Pakistan, it is recommended that the relevant degree programme holders (but not limited to) are eligible for induction as faculty member in Energy Systems Engineering at HEIs in Pakistan:
    - Agricultural Engineering
    - Biosystems Engineering
    - Civil Engineering
    - Chemical Engineering
    - Electrical / Electronic Engineering
    - Energy Systems Engineering / Energy Engineering
    - Environmental Engineering
    - Mechanical Engineering
    - Mechatronics
    - Petro-Gas Engineering
8. HRD facilities for training of faculty members through FDTP in Energy Systems Engineering programme should be encourgaed by HEC on priority basis.
9. The energy centers / energy parks should be established to improve the R&D facilities at the universities offering program in Energy Systems Engineering.
10. Higher Education Commission should facilitate (provision of development budget) in establishing required labs at the Universities to strengthen the discipline of Energy Systems Engineering.
11. HEC should provide funds for hiring short term visiting faculty from academia and industry for teaching specialized courses of the programme.

Prof. Dr. Zahid Mahmood (CONVENER) ----------

Dr. Anjum Munir (SECRETARY) ----------

Mr. Rabeel Bhatti (COORDINATOR) ----------

Mission Statement

To produce trained human resource in the discipline of Energy Systems Engineering for exploiting energy resources to enhance economic growth of the country.

Justification

Potential exists for almost all types of renewable energies in Pakistan. These types include solar (PV and thermal), wind, biogas, micro-hydel/canal fall, biodiesel production, biomass/waste to energy production, geothermal, tidal/ocean energies, etc. On an average, solar global insolation 5–7 kWh/m^2/day exists in the country over more than 95% of its area. Wind speed 5–7 m/s persist in coastal regions of Sindh and Balochistan provinces and in a number of North West frontier valleys. According to a survey, Pakistan possesses more than 50,000 MW of economically viable wind power potential.

The rise in global energy demand has raised questions regarding energy security and increased the focus on diversification, generation and efficient allocation. The answer lies in the attainment of optimal energy mix through fuel substitution by promoting energy efficiency and renewable energy and interregional co-operation. However, oil and natural gas will continue to be the world's top two energy sources through 2040.

Pakistan's economy has been growing at an average growth rate of almost 3 percent for the last four years and demand of energy both at production and consumer end is increasing rapidly. Knowing that there is a strong relationship between economic growth and energy demand, the government is making all possible efforts to address the challenges of rising energy demand

The Government of Pakistan is taking up the challenge of energy crises and trying to build a comprehensive plan of work in order to address the grave situation being faced by the country. Both the public and private energy sectors can address biomass/biogas, solar, micro-hydel and to some extent solid waste. Energy production by all the above means is established internationally and nationally. There is a need to strengthen all the stake holders engaged in trying to explore possibilities of utilizing renewable energy in place of traditional scarce and expensive fossil fuel energy supplies.

Pakistan is blessed with 900 km long coastal belt having a huge potential of tidal and wind energy that needs to be exploited for power generation to meet the energy needs of the coastal area.

Huge untapped coal resources approximately 185 billion tones lying unintended in Thar Sindh can be explored and utilized to generate power in-order to meet the national energy needs.

The solar photovoltaic (PV) systems in Pakistan is another resource still requiring special attention to be focused for utilizing in pumping water at

farms. The solar thermal applications can be used for steam generation, power generation, food processing, and essential oils extraction from medicinal plants. A huge amount of bio-waste from agriculture industry and household is another source of energy which can enable to produce more than 3000 MW in Pakistan. The energy produced from the biomass can be easily consumed in farm engines to pump water and other farm power operations. Additionally, the sugar mills producing biomass from sugarcane as a byproduct can be utilized to produce electricity.

Program Objectives

- To impart sound engineering knowledge for developing efficient energy systems.
- To develop skills for solving energy needs by integrating science and engineering principles adaptable to changing organizational and social needs;
- To engage in individual projects and multi-disciplinary teams designing, evaluating, and recommending methods and strategies for the efficient production, processing and utilization of renewable or non-renewable energy and addressing the associated environmental challenges;
- Effectively communicating with management, coworkers, customers, clients and others in diverse environments;
- Engaged in life-long learning process to maintain professional competency through training, participation in professional activities and leadership.
- Employed in the public or private sectors in the areas of energy science, energy engineering or energy business management, or pursuing an advanced degree.

Department of Energy Systems Engineering

Overview

Energy Engineering is an exciting and unique undergraduate program which we are going offer to meet energy crises by opening a new Department of Renewable Energy Engineering. This BS/BSc/BE degree is a first of its kind in the country with the curriculum addressing the call for the development of alternative sources of energy and conventional fossil fuels at the undergraduate level.

More specifically, the program will incorporate elements of the old Fuel Science undergraduate program with the addition of courses focused on renewable energy and agro-energy engineering as well as professional electives on business, finance, and management. Graduates of the program will be able to understand engineering fundamentals and apply that knowledge to solving problems in the production, processing, storage, distribution, and utilization of energy using multiple techniques such as

synthesis, analysis, design, and case studies and to incorporate with the agricultural processes.

This flexibility in the curriculum will make it an attractive dual or concurrent major and minor option for students in other energy-related programs as it prepares students to become valuable contributors in addressing society's energy needs and demands particularly in the field of agriculture. In addition, the program will prepare students to be successful leaders in advancing the technology and management of energy; innovators and entrepreneurs in the energy sector; and academia, practicing engineers, and national leaders in the energy and associated environmental health and safety, policy and economic fields.

It will train students to be lifelong learners, problem solvers, and energy industry leaders. The curriculum will be sufficiently flexible, broad, and diverse to enable students to tailor their educational experience to particular interests, background, and expected role in the field of agriculture and society. The flexibility allows students in energy related programs such as agricultural and biological, chemical, electrical, environmental, mechanical, nuclear, and petroleum engineering, materials science and engineering, industrial health and safety, and business and finance to have dual or concurrent degrees, minors, or options.

Career Opportunities

With the world's thirst for energy continuing to grow, there is now an urgent demand for a well trained workforce to develop process, utilize and manage conventional, unconventional, and renewable energy sources in an environmentally safe and economically feasible way. Therefore, graduates of the Energy Engineering program will have many diverse options that include the opportunity to:

- Become valuable contributors in addressing society's energy needs and demands, successful leaders in advancing the technology and management of energy, innovators and entrepreneurs in the energy sector.
- Join the workforce or continue on for advanced degrees in various areas of energy science, engineering, and business/management.
- Enter private or public sectors as Energy Engineers to evaluate and recommend energy generation, production and processing methods and strategies.
- Address critical energy management issues of various process industries especially extraction, production and conversion industries; design engineering systems to address energy production, processing and utilization.
- Contribute in designing/ developing novel catalytic/biological/chemical processes and/or maintaining upstream technologies for petroleum and natural gas processing

industries or unconventional fuels such as coal to liquids or oil shale/ tar sands processing industries.

- Join automobile manufacturing industries to work in traditional internal combustion engines or develop novel fuel cell based vehicles.
- Join major power companies in designing/maintaining/developing environmentally sound renewable power systems such as wind, solar, hydro, and geothermal or coal, oil, or gas based power generation systems.

Internship Opportunities

Students enrolled in "Energy Systems Engineering" will have the opportunity to participate in the DOE Technical Careers Internship Program. The Departments of Energy may initiate the internship program to recruit qualified students.

Degree Requirements

The first two years of the program are focused on fundamental engineering courses. Thereafter, one takes a series of courses that strengthen the "Energy Systems Engineering" concept. Fundamental energy engineering principles involve material and energy balances, thermodynamics, fluid mechanics, heat and mass transfer operations, and physical and chemical processing as applied to energy industries. In addition to these engineering principles, students enroll in required courses in renewable energy principles. Students will be trained in basic chemistry of fuels - coal, petroleum, natural gas and biomass; combustion; petroleum and natural gas processing; electrochemical energy conversion; and energy conversion processes including chemical, nuclear, biological and catalytic. Students also choose departmental electives from courses such as green energy engineering and environmental compliance, hydrogen and fuel cell technology, materials for energy applications, physical processes in energy engineering, and air pollutants from combustion sources. Professional electives allow students to gain exposure to business, legal and ethical issues related to energy. Technical electives can be chosen to provide specialization or breadth and depth in renewable or non-renewable energy and/or mechanical or chemical aspects of energy.
Students will also have opportunities to conduct independent research and participate in capstone design team projects with students from other engineering disciplines.

Expected Outcomes

If the curriculum prescribed for the undergraduate students is implemented effectively, the Energy Systems Engineering graduates would:

a. Possess essential engineering knowledge for meeting the requirements of industries and other organizations needing graduate engineers.
b. Have the academic background and basic research skills to pursue graduate studies at national and international level.
c. Possess the basic design/development skills and management/economic know how to enter the market as an entrepreneur.
d. Applying engineering knowledge, mathematical models and probabilistic/statistical tools to solve problems relating to energy.
e. Exploit renewable energy resources using hardware and software to solve the energy crises and to provide new solutions using innovative designs and techniques.
f. Function effectively in multi-disciplinary team for energy solutions.
g. Engage himself/herself in a lifelong learning process.
h. Acquire knowledge of contemporary issues and their correlation with the technologies.
i. Avoid real and perceived conflicts of interest whenever possible and disclose them to affected parties when they do exist.
j. Be honest and realistic in stating claims or estimates based on available data and reject bribery in its all forms
k. Seek, accept and offer honest criticism of technical work, acknowledge and correct errors and credit properly the contributions of others.
l. Treat fairly all persons regardless of such factors as raised religion, gender, disability, age, or regional origin.
m. Avoid damaging assets, reputation or employment by false or malicious actions.
n. Assist colleagues and co-workers in their professional development and support them in following the ethics.

BS/BSc/BE Energy Systems Engineering

Duration:	4 years
Number of semesters:	8
Number of weeks per semester:	16 - 18 (minimum 16 weeks for teaching and 2 weeks for examinations)
Total number of credit hours:	136
Number of credit hours per semester:	14 - 20

Scheme of Studies of BS/BSc./BE Energy Systems Engineering

First Semester

*Course No.	Title of the Course	Credit Hours
Engineering Courses		
ESE-	Metallurgy & Workshop Practices	4(2-2)
ESE-	Engineering Mechanics	3(2-1)
Non-Engineering Courses		
	Islamic Studies or Ethics (for Non-Muslim students)	2(2-0)
	Linear Algebra & Calculus	3(3-0)
	Applied Physics	3(2-1)
	Organic Chemistry	3(2-1)
	Total Credit hours	**18(13-5)**

Second Semester

Engineering Courses		
ESE-	Introduction to Energy Systems Engineering	2(2-0)
ESE-	Manufacturing Engineering	3(2-1)
ESE-	Fluid Mechanics	4(3-1)
ESE-	Engineering Drawing, Graphics, and CAD	3(2-1)
Non-Engineering Courses		
	Computer Programming Fundamentals for Engineers	3(2-1)
	Differential Equations, Power Series, Laplace Transform	3(3-0)
	Total Credit hours	**18(14-4)**

Third Semester

Engineering Courses		
ESE-	Basic Electrical Circuits and Network Analysis	3(2-1)
ESE-	Engineering Thermodynamics	4(3-1)
ESE-	Engineering Numerical Analysis	3(2-1)
Non-Engineering Courses		
	Pakistan Studies	2(2-0)
	English Composition and Comprehension	3(3-0)

	Sociology for Engineers	2(2-0)
	Total Credit hours	**17(14-3)**

Fourth semester

Engineering Courses		
ESE-	Instrumentation & Measurements	4(3-1)
ESE-	Mechanics of Materials	3(2-1)
ESE-	Heat and Mass Transfer	3(2-1)
Non-Engineering Courses		
	Communication & Presentation Skills	3(3-0)
	Statistics and Probability	3(3-0)
	Operations Management	2(2-0)
	Total Credit hours	**18(15-3)**

Fifth Semester

Engineering Courses		
ESE-	Solar Energy Systems	4(3-1)
ESE-	Wind and Hydropower Conversion	4(3-1)
ESE-	Energy Storage Technologies	2(2-0)
ESE-	Boiler Engineering and Power Plants	3(2-1)
ESE-	Power Transmission, Distribution & Utilization	4(3-1)
Non-Engineering Courses		
	Non-Engineering Elective Course	2(2-0)
	Total Credit Hours	**19(15-4)**

Sixth Semester

Engineering Courses		
ESE-	Petroleum and Gas Exploration	3(2-1)
ESE-	I.C. Engines	3(2-1)
ESE-	RS & GIS for Renewable Energy Resources	3(2-1)
ESE-	Heating, Ventilation and Air Conditioning Systems	4(3-1)
Non-Engineering Course		
	Microbial Bioenergy and Biofuels	3(2-1)
	Total Credit Hours	**16(11-5)**

Seventh Semester

Engineering Courses		
ESE-	Energy Conservation and Auditing	3(3-0)
ESE-	Bio-Energy Engineering	3(2-1)
ESE-	Project and Report-I	3(0-3)
ESE-	Engineering Elective-I	3(2-1)
ESE-	Engineering Elective-II	3(3-0)
	Total Credit Hours	**15(10-5)**

Eighth Semester

Engineering Courses		
ESE-	Power Electronics	3(2-1)
ESE-	Energy Economics, Policy and Management	3(3-0)
ESE-	Project & Report-II	3(0-3)
ESE-	Engineering Elective-III	3(2-1)
ESE-	Engineering Elective-IV	3(3-0)
	Total Credit Hours	**15(10-5)**

Total Credit Hours for B.Sc. Energy Systems Engineering = 136

Note:

1. **A supervised internship training to be arranged by the Institution after sixth semester as the requirement of the degree (Grades: Excellent, Good, Satisfactory)**
2. **Project and Report will be completed in two semesters i.e. 7th and 8th.**

Non-Engineering Elective

1. Photoactive Materials and Their Characterization 2(2-0)
2. Professional Ethics 2(2-0)
3. Energy and Environment 2(2-0)

Engineering Elective-I

- Renewable Energy Systems 3(2-1)
- Hydrogen and Fuel Cells 3(2-1)
- Control Systems 3(2-1)

Engineering Elective-II

- Geothermal and Tidal Energy 3(3-0)
- Nano Technology and Energy 3(3-0)

- Machine Design 3(3-0)

Engineering Elective-III

- Clean Coal Technology 3(2-1)
- Fuels & combustion 3(2-1)
- Electrical Machines 3(2-1)

Engineering Elective-IV

- Dynamics and Mechanisms of Machinery 3(3-0)
- Nuclear Energy Engineering 3(3-0)
- Environmental Impact Assessment 3(3-0)

ESE-	METALLURGY AND WORKSHOP PRACTICES	4(2-2)

Contact Hours:
Theory =32
Practical = 96
Total =128

Credit Hours:
Theory = **2.0**
Practical = 2**.0**
Total = **4.0**

Course outcome:

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

Ser	CLO	Domain	Taxonomy level	PLO
1.	**ACQUIRE** the basic knowledge of materials, their properties and heat treatments.	Cognitive	2	1
2.	**ANALYZE** the problems related with selection of materials and processing.	Cognitive	3	2
3.	**DEMONSTRATE** individually the operations and processes used in workshop	Psychomotor	3	3

Course outline:

1. Introduction

a. Safety and first aid in a mechanical lab
b. Production and properties of common engineering materials: Ferrous metals, iron ores, properties and uses of pig iron,

cast iron, wrought iron, steel, standard processes of manufacturing of Iron and steel

c. Open hearth process, basic oxygen processes, production of ingots.

2. Alloy Steel and Irons

a. Effect of alloying elements
b. The AISI/SAE alloy steel and their identification
c. Corrosion resistant steel, steel for high temperature services, alloy steel.

3. Non-ferrous metals:

a. Properties and uses of copper, aluminum, zinc, tin, nickel, and lead. Non-ferrous alloys, copper alloys. Aluminum alloys, zinc base alloys, nickel base alloys. Lead-tin alloys, iron-carbon equilibrium diagram

4. Theory and process of heat treatment of metals

a. Heat treatment of steel, annealing, hardening, tempering, normalizing, surface hardening, quenching
b. Heat treatment equipment.

5. Different hand tools used in workshop

a. Screw drivers, pliers, spanners, hammers, chisels, etc

6. Introduction to Workshop Machine Tools

a. Lathe machine (Conventional and CNC)
b. Milling machine
c. Shaper and Planner
d. Drilling, Bending, Cutting etc

7. Welding

a. Types of welding process, and welding materials, electric arc welding, oxy acetylene welding
b. Inspection and testing of welded joints,
c. Welding flames and materials, and cutting of metals using oxy acetylene welding.

8. Foundry

a. Casting and hand molding tools
b. Foundry cores, properties of core and, crucibles, handling and care

Practical:

Experiments related to Metallurgy and Workshop will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. Chapman, W.A.J. 2004. Workshop Technology Part-I. and II. Viva Books Private Ltd., India.
2. Johan, K.C. 2010. Mechanical Workshop Practices, 2nd Ed. Prentice-Hall of India Private Ltd., India.
3. 3.Ostwald, P.H. and J. Munoz. 2002. Manufacturing Processes and Systems, 9th Ed. John wiley and Sons, New York. USA.
4. Rao.P.N. 2002. Manufacturing Technology: Metal cutting and machine tools.Tata McGraw, Hill Co. Ltd., New Delhi, India

ESE-	**Engineering Mechanics**	**3(2-1)**

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

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

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** fundamental concepts of vectors and scalars, forces, moments, couples, resultants, kinematics, and kinetics of particles	Cognitive	2	1
2.	**APPLY** the learned concepts and laws to solve problems of bodies in 2-D	Cognitive	3	2
3.	**CALCULATE** various learnt parameters related to rigid bodies and the kinematics of rigid bodies	Psychomotor	3	3

Course outline:

1. Statics

a. Introduction to Mechanics, Basic Concepts of measurement of mass, force, time and space
b. Newton's Laws, Law of Gravitation
c. General Principles of Statics, Vector addition, Subtraction and Products
d. Force System, Two dimensional force system
e. Laws of Triangle, Parallelogram and Polygon of forces
f. Rectangular components
g. Moment, Couple, Resultant
h. Equilibrium in 2-D, System Isolation and free body diagram
i. Structures, Plan trusses, Method of Joints and section in trusses
j. Center of mass and centroid, centroid of line, area, volume
k. Distributed Forces, center of mass, centroid of composite bodies
l. Theorem of Pappus for area and volume
m. Friction, Problem involving friction on Flat surfaces
n. Types of beams, Supports and Loads, Simple cases of Axial forces

2. Dynamics

a. Introduction to Dynamics, Newton's Laws of Motion
b. Kinematics and Kinetics
c. Kinematics of Particles: Rectilinear Motion, Polar coordinates, relative motion
d. Kinetics of Particles, Force, Mass and Acceleration
e. Rectilinear and Curvilinear motions, Tangential and Normal Components of Acceleration
f. Simple Harmonic motion
g. Kinetics of Particles: work, Energy, Power
h. Impulse and Momentum
i. Conservation of Momentum and Energy
j. Kinetics of Systems of particles
k. Plane Kinematics of Rigid Bodies
l. Introduction to 3-D problems in mechanics

Practical:

Experiments related to Engineering Mechanics will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits

- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. Meriam, J.L. and L.G. Kraige. Engineering Mechanics. Statics, 7th Edition, John Willy and Sons, New York. 2014 ISBN: 9788126543960.
2. Meriam, J.L. and L.G. Kraige. Engineering Mechanics. Dynamics. John Willy and Sons, New York (Latest Edition)
3. Engineering Mechanics: Dynamics by Hibbeler R C (LatestEdition).
4. Engineering Mechanics: Statics by Hibbeler R C (14th Edition). 2016. ISBN: 9780133918922
5. Riley, W. & Struges, C.D. Engineering Mechanics, Static's and Dynamites, John Wiley & Sons Inc., New York. (Latest Edition)
6. Singer, F.L. Engineering Mechanics. Harper and Row Publishers, New York. (Latest Edition)

ESE-	Introduction to Energy Systems Engineering	2(2-0)

Contact Hours:
Theory = 32
Practical = 00
Total = 32

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

Course outcome:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** and be aware of the importance of sustainable energy	Cognitive	2	1
2.	**ACQUIRE** knowledge of technologies for generating energy for stationary applications, including fossil fuels combustion, solar energy, wind energy and biological energy.	Cognitive	4	2

Course outline:

History of energy usage, forms of energy, present energy consumption, environmental problems, Current status of conventional and renewable energy sources: World and Pakistan scenario, energy and power;

1. **Fossil Fuel Resources (Oil, Gas, Coal)**

2. **Solar thermal energy**
   a. Solar radiation resource
   b. Passive and active solar heating
   c. Solar concentrators
3. **Solar photovoltaic**
   a. Components of PV systems and operation
4. **Biomass**
   a. Biomass resource
   b. Extracting biomass energy
   c. Fuel crops
   d. Anaerobic digestion
   e. Landfill gas
   f. Waste to energy
5. **Hydroelectricity**
   a. Hydro power Resource
   b. Hydropower power equation
   c. Introdution to turbines
   d. Large and small scale systems
   e. Pumped storage.
   f. Tidal Power
   g. The tides, tidal resource, system operation, environmental factors
6. **Wind energy**
   a. Generation of the winds
   b. Wind resource
   c. Basic aerodynamics (lift versus drag) and the fundamental power equation
   d. Fundamental design concepts.
7. **Wave energy**
   a. The wave resource
   b. The fundamental power equation
   c. Onshore and off-shore wave energy extraction systems
8. **Geothermal Energy**
   a. Nature of fields
   b. Classification of Geothermal Resources
   c. Introduction to geothermal steam electric plants
   d. Liquid Dominated System: Flashed Steam System, Total Flow Concept, Geothermal exploration

9. Fuel Cell

e. Introduction and Classification,
f. Reactions and Configurations

10. Nuclear Energy

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Suggested Readings

1. Duffie, J.A. and W.A. Beckman. 2013. Solar Engineering of Thermal Processes, 3rd Edition, John Wiley & Sons.
2. Boyle, G. Renewable Energy: Power for a Sustainable Future. 2nd Edition, OUP and Open University, 2004, ISBN 019926178-4.
3. Boyle, G., B. Everett, and J. Ramage. 2003. Energy Systems and Sustainability, OUP and Open University, 2004, ISBN-13: 978-0199261796.
4. Scheer, H., A Solar Manifesto, James & James, 2004, ISBN 1 902916 24 7.
5. Kalogirou, S.A. 2009. Solar Energy Engineering: Processes and Systems. 1st Ed. British Library. ISBN 978-0-12-374501-9. Printed in USA.
6. B. Viswanathan, M. Aulice Scibioh. 2007. Fuel Cells: Principles and Applications. Taylor & Francis Group, 2007.

ESE	Manufacturing Engineering	3(2-1)

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

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

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**ACQUIRE** the knowledge of manufacturing	Cognitive	2	1

	processes, computer aided manufacturing (CAM) and computerized numerical control (CNC) machines and **UNDERSTAND** the concepts of manufacturing techniques for industrial applications.			
2.	**SOLVE** the problems in manufacturing industry employing CAM and CNC solutions.	Cognitive	4	2
3.	**DEMONSTRATE** individually the operation and applications of lathe, drilling, milling and advanced CNC machines in manufacturing sector.	Psychomotor	3	3

Course outline:

1. Introduction to lathe machines
- a. Turning and related operations
- b. Types and construction of lathe and its accessories
- c. Lathe operations
- d. Turret lathe and turret lathe tooling
- e. Mechanism of chip formation
- f. Type of cutting tools and their materials
- g. Tool failure, tool life and use of coolants.

2. Drilling and Reaming
- a. Type of drilling machines, drill bits and drill chucks
- b. Counter boring and sinking, boring and reaming practices and tools
- c. Estimating drilling time

3. Milling machines
- a. Types and working principle of milling machines
- b. Milling operations and mill cutters
- c. Estimating milling time.

4. Shaping and Planning
- a. Types of shaper and planers and their applications
- b. Shaper drive mechanism
- c. Shaper speeds and machining times
- d. Construction and types of planning machines.
- e. Planer tools and work set up methods
- f. Metal bending and sheet rolling processes

5. CAD and CIM Systems

a. Computer aided manufacturing and computer integrated manufacturing systems
b. Type of CNC machines and their working principles
c. Programming for numerical control
d. Machine tool control

6. Welding processes

a. Classification and application of welding processes
b. Oxyacetylene gas welding (OAW)
c. Shielded metal arc welding (SMAW)
d. Designation system for arc welding electrode
e. Resistance spot welding (RSW)
f. Resistance seam welding (RSW)
g. Forge welding (FOW)
h. Weldability and weld quality
i. Weld design and process selection

Practical:

Experiments related to Manufacturing Engineering will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. Kalpakjian, S. and S. Schmid. 2007. Manufacturing Processes for E Ed. Pearson Education, New Delhi. India.
2. Kalpakjin, S. and R.S. Schmid. 2004. Manufacturing engineering anc McGraw Hill Co. Ltd, New Delhi. India.
3. Ostwald, P.H. and J. Munoz. 2002. Manufacturing Processes anc Wiley and Sons, New York. USA.
4. Rao, P.N. 2005. CAD/CAM -Principles and applications, 2nd Ed. T New Delhi. India.

ESE-	Fluid Mechanics	4(3-1)

Contact Hours:
Theory = 48
Practical = 48

Credit Hours:
Theory = **3.0**
Practical = **1.0**

Total = 96 Total = **4.0**

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**EXPLAIN** the fundamental properties of fluids, including viscosity, Newtonian and nonNewtonian rheology, and viscoelasticity	Cognitive	2	1
2.	**ANALYZE** systems using macroscopic fluid mechanics, using the integral form of the conservation equations	Cognitive	4	2
3	**IDENTIFY** the relevant parameters that govern a fluid system and use dimensional analysis to identify the fundamental variables that define flow	Cognitive	3	2
4.	**EVALUATE** pressure distributions in a static fluid, taking account of hydrostatic pressure, buoyancy force, and interfacial tension (Laplace pressure and capillary action)	Psychomotor	3	3

Course outline:

1. **Introduction**
   a. Thinking about fluid mechanics
   b. Physics
   c. Formulation
   d. Macroscopic vs. Microscopic
   e. Fluid Flow and Viscosity
2. **Rheological Properties of Fluids**
   a. Continuum Hypothesis
   b. Conservation Laws
   c. Newton's law of viscosity

d. Rheological classifications

3. Fluid Statics

a. Pressure force on a fluid element
b. Hydrostatics and buoyancy
c. Surface Tension and Capillary force

4. Conservation Equations

a. Introduction to momentum balances for fluids
b. One-dimensional flow
c. Derivation of differential forms of conservation eqution
d. Equation of continuity
e. Equation of motion
f. Pipe-Flow and Haugen-Poiseuille
g. Deformation and vorticity

5. Approximations and solutions for Navier-Stokes

a. Dimensional analysis of conservation equations
b. Solutions in Cartesian, cylindrical and spherical coordinates
c. Similarity transforms
d. Time dependent flows
e. Creeping flow (low Reynolds number flow)
f. Lubrication flow
g. Stream functions and stream lines

6. Turbulence

a. Time averages and fluctuations
b. Derivation of Reynolds stresses
c. Turbulent velocity profiles
d. Transition into chaotic turbulent flow
e. Boundary layer Theory
f. Concept of boundary layer

7. Macroscopic Balances

a. Derivation of Macroscopic Mass, momentum and energy balances
b. Examples using Bernoulli's equation

8. Design Problems

a. Pressure drops in piping
b. Dimensions of pipes
c. Energy requirements for pumps and turbines

Practical:

Experiments related to Fluid Mechanics will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. Yunus Cengel and John Cimbala, 2013. Fluid Mechanics Fundamentals and Applications
2. Franzini, J.B. and Finnemore, E.J. 2003. Fluid Mechanics with Engineering Application. McGraw Hill Book Co., Singapore.
3. Jain, A.K. 1990. Fluid Mechanics: A Text Book for Engineering Students. Khana Publishers, New Delhi, India.
4. Streeter, V.L. 1988. Fluid Mechanics. McGraw Hill Inc., New York.
5. Daughterty, R.I., J.B., Franzini, and E.J. Finnemore. 1995. Fluid Mechanics with Engineering Application, McGraw Hill Book Co. Singapore.
6. Frank White, 2010. Fluid Mechanics McGraw-Hill Series

ESE-	Engineering Drawing, Graphics, and CAD	3(2-1)

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

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

Course outcome:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**ACQUIRE** the basic knowledge of drawing skills.	Cognitive	2	1
2.	**APPLY** the concepts of basic drawing techniques.	Cognitive	3	2
3.	**DEMONSTRATE** individually the drawings of plan, elevation and cross sections of machine parts	Cognitive	3	2
4.	**DEMONSTRATE** the 3D model of the machine elements using modern tool.	Cognitive	3	2

Course outline:

Engineering Graphics (Theory)

1. **Orthographic Projection**
   a. Principle and Methods of projection,
   b. Orthographic projection,
   c. Planes of projection,
   d. First and Third-angle projection,
   e. Reference line
2. **Projection of Points**
   a. A point is situated in the first, second, third and fourth quadrant
3. **Projection of Straight Lines**
   a. Line parallel and perpendicular to one or both the planes,
   b. Line contained by one or both the planes,
   c. Projections of lines inclined to both the planes,
   d. True length of a straight line and its inclinations,
   e. Methods of determining traces of a line
4. **Projection of Planes (2D)**
   a. Types and Traces of planes,
   b. Projections of planes,
   c. Projections of oblique planes
5. **Projections on Auxiliary Planes (2D)**
   a. Types of auxiliary planes and views,
   b. Projection of a point on an auxiliary plane,
   c. Projections of lines and planes
6. **Projections of Solids (3D)**
   a. Types of solids and their projections,
   b. Projections of solids with axes inclined
7. **Section of Solids (3D)**
   a. Section of planes, prisms, pyramids, cylinders, cones, spheres,
   b. Methods of development,
   c. Triangulation development,
   d. Developments of lateral surfaces of right solids
8. **Isometric Projections (3D)**
   a. Isometric axes, lines, planes, and scale,
   b. Isometric drawing or isometric view,
   c. Isometric drawing of planes or plane figures, prisms and pyramids, cylinders, cones and sphere

Engineering Drawing (Lab):

1. **Introduction**
   a. Introduction to Engineering Drawing, I. S. specification for preparation of drawings,

b. Use of drawing instruments and materials,
c. Basic Tools, Lines: Types, configuration and application, Selection of line thickness

2. Lettering, Numbering and Dimensioning

a. Vertical and inclined single stroke letters,
b. Lettering types and rules,
c. Dimension lines, projection lines, leaders or pointer lines,
d. Arrow heads, Dimensioning,

3. Geometric Construction

a. Drawing simple geometric objects (polygon, pentagon and hexagons etc).

4. Orthographic Projections of different Solids

5. Orthographic Projections of Machine Elements

a. Rivets, Nut and bolts,
b. Different kinds of threads,
c. Lap and butt joints, Flange couplings,
d. Journal bearing,
e. Open bearing,
f. Footstep bearing,
g. Crankshaft,
h. Bearings

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. D Bhatt, Engineering Drawing and Graphics, BS Publications.
2. B. Wiebe and M. Mohler ,Technical Graphics Communication, McGraw-Hill
3. W. Abbot, Practical Geometry & Engineering Graphics, Springer.
4. F. M. Craft, F. D. Meyers, E. T. Boyer and M. J. Miller and J. T. Demel, Engineering Graphics, John Wiley & Sons.
5. G. R. Bertoline and E. N. Wiebe, Technical Graphics Communication; McGraw-Hill.
6. D.F. Rogers and J.A. Adams; Mathematical Elements for Computer Graphics, McGraw-Hill.
7. C. Parkinson, A First Year Engineering Drawing, Sir Isaac Pitman & Sons.
8. R. Lal and R. Rana, A Textbook of Engineering Drawing: Along with an Introduction to AutoCAD, I K International Publishing House.
9. T. Jeyapoovan, Engineering Drawing and Graphics Using AutoCAD, Vikas Publishing.
10. Z. A. Siddiqui, M. Ashraf and S. A. Siddiqui. Basics of Engineering Drawing, M/S Technical Publishers.
11. D. A. Jolhe, Engineering Drawing with an introduction to AutoCAD, Tata McGraw-Hill Education.

ESE-	BASIC ELECTRICAL CIRCUITS AND NETWORK ANALYSIS	3(2-1)

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

Credit Hours:
Theory = **2.0**
Practical = 1**.0**
Total = **3.0**

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.NO	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the basic knowledge of electrical circuits along with working of individual components.	Cognitive	2	1
2.	**ANALYZE** the working of various electrical systems in an energy system.	Cognitive	4	2

3.	**DEMONSTRATE** the design of electrical circuits and basic electrical netwrokes as well as the calculations involved in their designing.	Psychomotor	2	3

Course outline:

a. Physical foundation of electric circuits; electric current; electromotive force
b. Resistance, conventional current
c. Ohm's law, work, energy, and power, conductance, efficiency, real and ideal sources, resistive networks
d. Kirchoff's voltage and current laws
e. Voltage divider rule, current divider rule, series- and parallel-connected sources
f. Voltage and current source conversions
g. Mesh analysis, nodal analysis, network theorems (Superposition, Thevenin's, Norton's, and Maximum Power Transfer) with independent and dependent sources
h. Capacitance and capacitors, inductance and inductors
i. Electromagnetic induction, alternating current fundamentals, phasor representation of alternating current,
j. AC voltage and current relationships for pure resistance, inductive and capacitive circuits,
k. Wye-delta transformations
l. Integro-differential equations of circuits, transient analysis, source-free series and parallel LC circuits,
m. Complete response of RLC circuit, resonance; lossless LC circuit
n. Complex forcing functions
o. Phase relationships for R, L and C impedance and admittance
p. Sinusoidal steady-state response
q. Power factor and power factor improvement;
r. Complex frequency, frequency-domain analysis
s. Network analysis in the s-domain

Practical:

Study of DC series circuits, parallel circuits, Kirchhoff's current and voltage laws, current divider theorem, voltage divider theorem, network theorems, simple RLC circuits, transformer operation, and simulation of basic electrical circuits using PSPICE.Basic RL and RC circuits, RLC circuit, sinusoidal steady-state analysis, AC power circuit analysis

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. Electrical technology, Edward Hughes ,Longman Latest edition,
2. Principles of Electrical Engg.,B.R Gupta ,S. Chand and Company
3. Basic Electrical Engg. Science ,Mc Kenzie Smith,Longman
4. Storey, N. 2004. Electrical & Electronics Systems, Prentice Hall, 1/E, ISBN-10: 0130930466.
5. Warnes, L. 2008. Electronic and Electrical Engineering Principles and Practice, Macmillan, ISBN-10: 0333990404.
6. Storey, N. 2006. Electronics: A Systems Approach, Prentice Hall, 3/E, ISBN-10: 0273694340.
7. Floyd, T.L. 2007. Electronics Fundamentals: Circuits, Devices and Applications: Prentice Hall, 7/E, ISBN-10: 0131995855.
8. Hambley, A.R. 2007. Electrical Engineering: Principles and Applications, Prentice Hall, 4/E, ISBN-10: 0131989227.
9. Mohan N., T. Undeland, W. Robbins. 2003. Power Electronics: Converters, Applications and Design. John Wiley & Sons, 2003.

ESE-	Engineering Thermodynamics	4(3-1)

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

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

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.NO	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the basic knowledge and concepts of laws of thermodynamics,	Cognitive	2	1

	processes, and cycles of operations in thermal systems.			
2	**ANALYZE** the problems regarding thermodynamics systems	Cognitive	4	2
3.	**DEMONSTRATE** individually the operation of thermal machines (heat engines and turbo machinery etc.)	Psychomotor	3	4

Course outline:

1. Introduction and Basic Concepts
- a. First law of thermodynamics and its applications
- b. System and boundary
- c. Specific volume, pressure and temperature

2. Energy, Energy Transfer, and General Energy Analysis
- a. Equilibrium state, processes
- b. Methods to solve thermodynamics problems

3. Properties of Pure Substances
- a. Phase change processes, P-v-T relation
- b. Property diagrams
- c. Equation of state, specific heats
- d. Compressibility polytropic process relation.

4. Energy Analysis of Closed Systems
- a. Energy balance of closed system

5. Mass and Energy Analysis of Control Volumes
- a. Energy analysis of power, refrigeration and heat pump cycles

6. The Second Law of Thermodynamics
- a. Spontaneous and non-spontaneous processes
- b. Thermodynamic cycles, irreversible and reversible process, and Carnot cycle
- c. Clausius inequality.

7. Entropy
- a. Entropy change, T-s diagram, entropy generation
- b. Increase of entropy principle, entropy rate balance of closed systems and control volumes
- c. Isentropic efficiencies

8. Exergy
- a. Exergy balance
- b. Exergetic efficiency

9. Gas Power Cycles

a. Air-Standard-Otto cycle
b. Diesel cycle,
c. Dual and Brayton cycle
d. Regenerative gas turbines with reheat & inter cooling
e. Combined cycles

10. Vapor and Combined Power Cycles

a. Modeling and analyzing
b. Superheat and Reheat vapor power cycles
c. Regenerative vapor power cycles
d. Other vapor cycle aspects

11. Refrigeration Cycles

a. Vapor compression refrigeration systems
b. Cascade and Multistage systems

Practical:

Experiments related to Engineering Thermodynamics will be covered.

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Industrial Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. Khurmi, R.S. and J.K. Gupta. 2000. Thermal Engineering. S. Chand & Co. Ltd., New Dehli, India.
2. Sontagg, R. E. and G. J. Van Wylen. 2010. Fundamentals of thermodynamics. 7th Ed., John Willey and Sons, Inc. New York, USA.
3. Jones, J.B. and G.A. Hawkais. 2002. Engineering Thermodynamics. John Willey and Sons, Inc. N.Y., USA.
4. Lewitt, E. H. 2002. Thermodynamics Applied to Heat Engines. Isaac Pitman and Sons, London.
5. Eastop, T. D. 2004. Applied Thermodynamics for Engineering and Technologists. 5th Ed. Pearson Education Singapore.
6. Yunus A. Cengel, Michael A., Thermodynamics: An Engineering Approach, McGraw-Hill.
7. M. J. Moran and H. O. Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley & Sons.
8. Sonntang, Borgnakke, Van Wylen John, Fundamentals of Thermodynamics, Wiley & Sons.

ESE-	Engineering Numerical Analysis	3(2-1)

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

Credit Hours:
Theory = **2.0**
Practical = 1**.0**
Total = **3.0**

Course outcome:

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

Ser	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the formulation, methodology, and techniques for numerical solution of engineering problems.	Cognitive	2	1
2.	**APPLY** the finite precision and the inherent limits of various numerical methods	Cognitive	3	2
3.	**DEMONSTRATE** the implementation of numerical solution algorithms	Cognitive	4	5

Course outlines:

1. **Finding roots of equations**
   a. Bisection
   b. Newton's method
2. **Solving systems of linear algebraic equations**
   a. Gauss Elimination
   b. LU factorization
   c. Gauss-Seidel
   d. MATLAB left division operator
   e. Curve fitting
   f. Least-squares regression
   g. Linearization of data
   h. Polynomial fitting
   i. Multiple linear regression
   j. MATLAB polyfit function
3. **Interpolation**
   a. Lagrange polynomials
   b. Splines
4. **Numerical Differentiation**

a. Finite differencing (backward, forward, central)
b. Higher-order schemes

5. Numerical Integration

a. Newton-Cotes
b. Romberg integration
c. Gauss Quadrature

6. Ordinary Differential Equations

a. Initial Value Problems 1. Runge-Kutta Methods 2. Systems of ODES 3.
b. Boundary Value Problems 1. Shooting Method 2. Direct Solution Method (Finite Difference) for linear BVPs

7. Optional Topics

a. Eigenvalues and Eigenvectors
b. Systems of nonlinear algebraic equations
c. Finite Difference Method for nonlinear BVPs
d. Spectral analysis (Fast Fourier Transform)
e. Partial Differential Equations

Practical:
Experiments related to Engineering Numerical Analysis will be covered.

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Industrial Visits
- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. Bhat, R.B. and S. Chakraverty. 2004. Numerical Analysis In Engineering. Alpha Science International.
2. Moin, P. 2010. Fundamentals of Engineering Numerical Analysis. Cambridge University Press.
3. Sastry, S.S. 2005.Introductory Methods of Numerical Analysis. PHI Learning Pvt. Ltd.

ESE-	Instrumentation & Measurements	4(3-1)

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

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.NO	CLO	Domain	Taxonomy level	PLO
1.	**EXPLAIN** the fundamentals of instrumentation and measurement systems.	Cognitive	2	1
2.	**ILLUSTRATE** signal conditioning principles and apply them in practical scenarios.	Cognitive	2	1
3.	**APPLY** the working principles of sensors and transducers and effectively choose a particular sensor/transducer for a particular application.	Cognitive	3	2
4.	**INVESTIGATE** the instrumentation and measurement system	Psychomotor	3	4

Course outlines:

1. Precision measurements terminologies and principles
2. Instruments for measurement of electrical and non-electrical quantities
3. Voltmeters,
4. Ammeters,
5. Function generators,
6. Oscilloscopes;
7. Systems for signal processing and signal transmission;
8. Modern instrumentation techniques;
9. Static and dynamic responses of instrumentation and signal conditioning;
10. Data acquisition systems;
11. Principles of operation,
12. Construction and working of different analog and digital meters,
13. Advanced Testing & Measuring instruments recording instruments,

14. Signal generators,
15. Sensors,
16. Input and output transducers;
17. Types of bridges for measurement of resistance,
18. Inductance, and capacitance;
19. Power and energy meters;
20. High-voltage measurements,
21. PLC systems

Practical:
Experiments related to Instrumentation & Measurements will be covered.

Teaching Methodology
- Lecturing
- Written Assignments
- Guest Speaker
- Industrial Visits
- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. Modern Electronic Instrumentation and Measurements Techniques by A.D.Helfrick, W.D. Cooper
2. Klaas B. Klaassen and Steve Gee, "Electronic Measurement and Instrumentation," 1996, Cambridge University Press, ISBN: 0521477298.T
3. H Kevin, JamesH, "PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control," 2000, Newnes, ISBN: 0750646241.
4. Alan S. Morris, Reza Langari, "Measurement and Instrumentation, Theory and Application", Elsevier, 2012, ISBN 978-0-12-381960-4
5. Electrical Instrumentation and Measurement techniques ,By A.K.Sawhney
6. Haslam, J.A, G.R. Summers, and D. Williams. 2014. Engineering instrumentation and control. Kindle Edition.
7. Bolton, W. 2014. Instrumentation and control system. Amazon Book company
8. Necsulescu, D. S. 2002. Mechatronics, Prentice Hall Inc., N.J., USA.
9. Figliola, R. S., and D. E. Beasley. 2004. Theory and design for Mechanical measurements. 3rd ed. John Willey & Sons (Asia) Pte, Inc. Singapore.

10. Dally, J. W., W. F. Riley and K. G. McConnel. 2003. Instrumentation for engineering measurements, 2nd ed. John Willey and Sons, Inc. Singapore.
11. Shetty, D. and R. A. Kolk. 2001. Mechatronics system design. Vikas Publishing House,Pvt, Ltd. New Delhi, India
12. Mahalik, N. P. 2003. Mechatronics, principles, concepts and applications. Tata McGraw Hill, New Delhi, India.

ESE	Mechanics of Materials	3(2-1)

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

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

Course outcome:

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

S.NO	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the fundamental concepts of solid mechanics (stress and strain	Cognitive	2	1
2.	**ANALYZE** the shear and bending moment diagram and Mohr's circle	Cognitive	4	2
3.	**DEMONSTRATE** the concepts of stress, strain, bending, torsion and deflection in various structures.	Psychomotor	3	4

Course outline:

1. Introduction
   a. Mechanical properties of materials
   b. Moment of inertia
   c. Hooke's law
2. Thermal stresses
   a. Stress due to axial forces
   b. Strain, properties of material under axial loading
3. Stress and strains

a. Stress at a point
b. Analysis of plane stress
c. Principle stresses
d. Maximum shear stress
e. Mohr's circle

4. Bending

a. Bending stresses in beams
b. Shear and bending moment diagrams

5. Combined loading

a. Stresses due to axial, bending and torsional loading

6. Deflection

a. Moment-curvature relationship
b. Deflection of beams by the method of double integration
c. Deflection of beams: Double integration method with singularity function
d. Area moment method

7. Torsion

a. Shearing stress and angle of twist
b. Hollow and circular shafts

8. Buckling

a. Pin ended column
b. Eccentrically loaded column
c. Initially curved column
d. Critical loads and critical stresses

9. Curved beams

a. Stresses in curved bars

10. Cylinders and spheres

a. Stresses in thin and thick walled cylinders

11. Fatigue loading

a. Analysis and design

Practical:

Experiments related to Mechanics of Materials will be covered.

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Industrial Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference Books:

1. Mechanics of Materials 6th/Ed BY F P Beer, E R Johnston. 2013. ISBN: 9781259097171
2. Mechanics of Materials 9th/Ed (Lpe) By Hibbeler R C. 2015. ISBN: 9789332518605
3. J. M. Gere and B. J. Goodno, Mechanics of Materials, Cengage Learning. ISBN: 9781111577742
4. Muvdi, B.B. and J.W. Mcnabb. Engineering Mechanics of Materials. Macmillan Publishing Co. New York (Latest Edition).
5. Shigley, J.E. and L.D. Mitchell. Mechanical Engineering Design. McGraw Hill Book Co. New York (Latest Edition).

ESE-	**Heat and Mass Transfer**	**3(2-1)**

Theory =32 Theory = **2.0**
Practical = 48 Practical = **1.0**
Total = 80 Total = **3.0**

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.NO	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the basic knowledge of modes of heat and mass transfer and their applications.	Cognitive	2	1
2.	**ANALYZE** the problems using suitable mode of heat and mass transfer in engineering application	Cognitive	4	2
3.	**DESIGN** distinct types of thermal systems.	Cognitive	5	3
4.	**DEMONSTRATE** individually operation of heat exchangers.	Psychomotor	3	4

Course outline:

1. Introduction

a. Introduction to conduction, convection and radiation heat transfer,

b. Thermodynamics and heat transfer,
c. Engineering techniques in heat transfer,
d. Different forms of energy,
e. Heat transfer mechanisms;

2. Conduction Heat transfer

a. Principles of conductive heat transfer,
b. Energy balances concerning heat transfer,
c. Heat transfer coefficient correlations, Equations of change for isothermal systems, macroscopic balances for isothermal systems,
d. Analytical, approximate solutions to equations of heat transfer,
e. Empirical model for the evaluation of conductive heat transfer coefficients.

3. Convection heat Transfer

a. Principles of convective heat transfer,
b. Shell balances concerning heat transfer,
c. Heat transfer coefficient correlations,
d. Boiling and condensation, transient heat transfer.
e. Equations of change for isothermal systems, macroscopic balances for isothermal systems,
f. Analytical, approximate solutions to equations of heat, transfer, momentum, energy transport, interphase momentum, heat transfer.
g. Empirical model of the evaluation of heat transfer coefficients.

4. Radiation Heat Transfer

a. Radiation properties, black body radiation, absorptivity, reflectivity, transmissivity,
b. Wien's law, Kirchoff's law, Grey body radiation,
c. Radiation shape factor and relations between shape factors,

5. Heat Exchangers

a. Principles of working of heat exchangers,
b. Thermal design of heat exchangers
c. Empirical model for the evaluation of heat transfer in heat exchangers

6. Mass Transfer

a. Analogy between heat and mass transfer,
b. Mass diffusion, boundary conditions, steady mass diffusion through a wall, transient mass diffusion, diffusion in moving medium,
c. Mass convection, simultaneous heat and mass transfer.
d. Principles of diffusion, mass transfer in turbulent flow,

e. Mass transfer theories, general principles of stage wise and continuous contacting operations, applications to absorption and distillation.

Practical:
Experiments related to Heat and Mass Transfer will be covered.

Teaching Methodology
- Lecturing
- Written Assignments
- Guest Speaker
- Industrial Visits
- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:
1. Heat Transfer by J. P. Holman, 10th Edition
2. Fundamentals of Heat and Mass Transfer by Incropera & Dewitt, 7th Edition
3. Heat Transfer, a practical approach by Y. A. Cengel, 2nd Edition
4. Principles of Heat Transfer by F. Kreith, 7th Edition

ESE-	**Solar Energy Systems**	**4(3-1)**

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

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

Course outcome:

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

S.NO	CLO	Domain	Taxonomy level	PLO
1.	**EXPLAIN** the technical and physical principles of solar cells and solar collectors	Cognitive	2	1
2.	**MEASURE** and evaluate different solar energy technologies through	Cognitive	3	2

	knowledge of the physical function of the devices,			
3	**DESIGN** the solar thermal and PV systems	Cognitive	2	2
5	**INVESTIGATE** the performance of solar thermal and PV systems	Psychomotor	3	4

Course outline:

1. **Photovoltaic Systems:**
   a. Prinicple and construction of solar cells,
   b. Types of solar cells,
   c. Semiconducting materials,
   d. Band gap theory,
   e. Absorption of photons,
   f. Excitons and photoemission of electrons,
   g. Band engineering;
   h. Solar cell properties and design;
   i. P-n junction photodiodes,
   j. Depletion region,
   k. Electrostatic field across the depletion layer,
   l. Electron and holes transports, device physics,
   m. Charge carrier generation, recombination and other losses,
   n. I-V characteristics, output power;
   o. Single junction and semiconducting materials for solar cells,
   p. Mono and poly crystalline solar cells,
   q. Amorphous solar cell/thin layer classification of solar systems (stand-alone, hybrid and grid-tied), effect of temperature and irradiance,
   r. PV sizing for all types of configurations (Stand-alone, grid-tied and hybrid) ,
   s. Parameters affecting performance evaluation of PV system, concept of Photovoltaic-thermal (PV-T)
2. **Solar Thermal Energy Systems:**
   a. Low, medium and high temperature collectors,
   b. types of solar energy collectors;
   c. Flat plate collectors,
   d. evacuated tube collectors,
   e. Concentrators,
   f. Solar heat storage systems,
   g. Solar thermal plant sizing.
   h. Thermoelectricity

Practical:

Experiments related to Solar Energy Systems will be covered.

Teaching Methodology

- Lecturing
- Written Assignments
- Guest Speaker
- Industrial Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Recommended Books

1. Duffie, J.A. and W.A. Beckman. 2013. Solar Engineering of Thermal Processes, 3rd Edition, John Wiley & Sons.
2. Green, M.A. 1998. Solar Cells: Operating Principles, Technology and system Applications, Kensington, N.S.W. University of New South Wales.
3. Goswami, D.Y. 2000. Principles of Solar Engineering, 2nd Ed. Taylor and Francis, USA.
4. and Francis, 2000, ISBN 10: 1-56032-714-6
5. Wenham, S.R., M.A. Green., M.E. Watt. And R. Corkish. 2012. Applied Photovoltaics, 3rd Ed. Routledge publishers .Earthscan, USA.
6. Lasnier, F. and T.G. Ang. 1990. Photovoltaic Engineering Handbook, Adam Hilger. 1st Ed. IOP Publishing Ltd, Bristol. USA.
7. Sze, S.M. 2001. Semiconductor Devices, Physics, and Technology, 2nd Ed. John Wiley & Sons, New York. USA.

ESE-	Wind and Hydro Power Conversion	4(3-1)

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

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

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.NO	CLO	Domain	Taxonomy level	PLO
1.	**APPLY** the governing equations of fluid flow and rotor dynamics to	Cognitive	3	1

	wind and hydr power systems			
2.	**ANALYZE** the turbine design parameters	Cognitive	4	2
3.	**DESIGN** the Wind and hydraulic turbine	Cognitive	5	3
4.	**DEMONSTRATE** individually the principle, performance and operation of wind and hydro power systems	Psychomotor	3	4

Course outline:

1. Introduction

a. Historical Perspective of Wind and Hydro potential
b. Installed capacity of Wind and Hydro Energy resources

2. Wind Energy Conversion

a. Components of Wind Turbine
b. Types of Wind Turbines and wind Farms,aerodynamics of wind turbine blades
c. Optimal Tip Speed Ratio ,blade Element Theory and BEM Method
d. Maximum Power and Bet'z limit,wind Farm Siting: onshore and offshore
e. Wind Wake and interdistance between wind turbines
f. Types of Generators used in Horizontal Axis Wind Turbine,grid Integration of Wind Farms

3. Hydro Power Conversion

a. Elements of Hydropower Plants
b. Pressure Pipes and tunnels
c. Design of Guide vanes
d. Reversible hydraulic machines
e. Characteristic curves
f. Control Protection Systems
g. Operation and Maintenance
h. Cables and Earthing Systems

Practical:

Experiments related to Wind and Hydro Power Conversion will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz

- Guest Speaker
- Field Visits
- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Recommended Books

1. Tony Burton, David Sharpte, N. Jenkins, E. Bossanyi. 2011. Wind Energy Handbook, John Wiley & Sons, Ltd. UK
2. Moore, T.R. and E.I. Bailey. 2012. Wind Power: Systems Engineering Applications and Design Models, Nova Science Publishers Inc, UK.
3. Wagner, H.J. and M. Jyotirmay. 2011. Introduction to Hydro Energy Systems, 1st Ed. Springer-Verlag Berlin Heidelberg.
4. Martin O.L. Hansen. 2013. Aerodynamics of Wind Turbines, EarthScan Publisher, UK

ESE-	ENERGY STORAGE TECHNOLOGIES	2(2-0)

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

Credit Hours:
Theory = **2.0**
Practical = **0**
Total = **2.0**

Course outcome:

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

S.NO	CLO	Domain	Taxonomy level	PLO
1.	**Comprehend** the fundamental knowledge to compare and contrast methods of energy storage management	Cognitive	2	1
2.	**Relate** concepts of energy storage integration in various energy distribution systems	Cognitive	4	2
3.	**Evaluate** the case studies/problems related to energy storage systems	Cognitive	4	2

Course outline:

1. **Introduction to Energy Storage**
   a. Introduction to the traditional bulk power system, its operation, layout and control.
   b. Design tradeoffs of applying energy storage solutions throughout the transmission,
   c. Sub-transmission and distribution networks.
   d. System impacts and effects of distributed generation on the operation and control of the bulk power system.

2. **Electrochemical Energy Storage**
3. **Batteries**
   a. Introduction to battery storage including lead acid, lithium ion, flow, and emerging battery technologies.
   b. Comprehensive analysis of design considerations and application specific needs.
   c. Impacts on system cost in terms of life cycle, environmental, and reliability of the end solutions.
4. **Ultra-Capacitors**
   a. Introduction to ultra-capacitors including operation applications, and emerging technologies.
   b. Topics include the usage in mobile applications and close proximity to renewable energy sources.
   c. Discussion of primary target market usage in today's energy and power sectors
5. **Super Conducting Magnetic Energy Storage**
   a. Introduction to Super Conducting Magnetic Energy Storage (SMES) operation,
   b. Theory of usage and emergent research.
   c. Case study large utility scale energy storage facilities
6. **Mobile vs. Fixed Energy Storage**
   a. Advantages and disadvantages of mobile vs. Stationary energy storage.
   b. Vehicle to grid applications and opportunities to leverage existing and emergent technology to provide additional grid support functions
7. **Mechanical Energy Storage**
8. **Pumped hydroelectric energy storage**
   a. Models for pumped hydro capacity and availability
   b. System cost
   c. Capacity
   d. Conversion efficiency case study
9. **Compressed Gas**
   a. Models for compressed gas capacity, efficiency, and availability.

b. System cost, capacity, conversion efficiency, and siting will be discussed along with barriers to adoption.
c. Possible applications in carbon capture and sequestration

10. Flywheel

a. Models for flywheel capacity, availability, efficiency, and self-discharge.
b. Applications in transportation, uninterruptible power supply (UPS), pulse power, and bulk storage.
c. Selection and design of flywheels for safety and availability in various applications.

11. Thermal Storage

a. Introduction to thermal storage with an emphasis on residential and utility scale applications including **molten salts, cold reservoirs, and phase change materials**.
b. Analysis of design considerations, material selection, and application specific constraints.
c. Applications in renewable energy particularly utility scale solar and geothermal power production.

12. Additional topics

a. Discussions relating to other forms of energy storage including carbon based solutions.
b. Discussion of tradeoffs and use cases of these solutions as well as their impacts on the environment.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. Ter-Gazarian, A.G. (2011) Energy Storage for Power Systems, 2nd Edition, IET Publications (ISBN: 978-1849192194) (TextBook)
2. Huggins, R.A. (2010) Energy Storage, Springer, (ISBN: ISBN 978-1441910240)
3. İbrahim Dincer, Marc A. Rosen (2011) Thermal Energy Storage; Systems and Applications, Second Edition, John Wiley & Sons, New York,
4. Lucas B. Hyman (2011) Sustainable Thermal Storage Systems: Planning, Design, and Operations, McGraw-Hill

5. Frank S. Barnes, Jonah G. Levine (2017) Large Energy Storage Systems Handbook (ISBN 9781138071964)

ESE-	Boiler Engineering and Power Plants	3(2-1)

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

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

Course outcome:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**ILLUSTRATE** the basic configuration of boilers and power plants technologies.	Cognitive	2	1
2.	**ANALYZE** various processes of boilers and power plants	Cognitive	4	2
3.	**DEMONSTRATE** working principle, operation and performance of boiler and gas turbines	Psychomotor	3	4

Course outline:

1. Boiler:

a. Introduction to boiler, its components, fuels and water treatment
b. Classification and description of steam boilers and comparison
c. Boiler mountings and accessories,
d. Properties of steam, use of steam tables, amount of steam produced, pressure and quality of steam, dryness fraction, enthalpy of wet steam
e. Performance of steam boilers, boiler efficiency
f. Design of boiler and pressure control system devices

g. Classification and combustion of various fuels in boilers, Heat account for boiler and turbine, amount of fuel burnt, analysis of flue gases

2. Boiler Draught:

a. Concept of forced, induced and balanced draught,
b. Secondary air systems, stacks

3. Steam Nozzles

a. Introduction, significance and types of steam nozzles, steam cycle
b. Velocity of steam flowing through nozzles
c. Mass of steam discharged through nozzles (critical pressure ratio), Mollier chart
d. Supersaturated expansion in nozzles, heat drop in saturated and supersaturated expansion, steam injector

4. Power Plants:

a. Introduction to steam power plants, general layout of modern steam plants
b. Impulse turbine, single and multi-stage steam turbine,
c. Work done, velocity diagram of single and multi-stage impulse and reaction turbine, work done in blading
d. Steam generators, engines and auxiliary components
e. Condenste recovery system and cooling tower
f. Co-generation and tri-generation systems

5. Gas Turbine

a. Introduction, the gas turbine cycle,
b. Isentropic efficiency of compressors and turbines
c. Intercooling and reheating, explosion type gas turbine with solar heating Development and improvement in gas turbine.
d. Jet propulsion plant, comparison of steam and gas power plants.

Practical:

Experiments related to Boiler Engineering and Power Plants will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. Chattopadhyay, P. 2000. Boiler Operation Engineering. TATA McGraw HillPub. Co. Ltd., New Dehli, India.
2. Kearton, W. J. 1999. Steam turbine theory and practice. 7th Ed. CB Spublishers & Distributors. New Delhi, India..
3. Granet, I. and M. Bluestein. 2001. Thermodynamics and heat power, Pearson Education Asia.
4. Cengel, Y. A. R. H. Turner. 2005. Fundamentals of thermal fluid sciences. McGraw Hill International.
5. Mohammad A Malek. Power Boiler Design, Inspection, and Repair: Per ASME Boiler and Pressure. McGraw-Hill Education; 1 edition (January 17, 2005)
6. Everett B. Woodruff, Herbert B. Lammers, Thomas F. Lammers. Steam Plant Operation, 10th Edition McGraw-Hill Education; 10 edition (November 3, 2016)
7. Amiya Ranjan Mallick (2015). Practical Boiler Operation Engineering and Power Plant. PHI Learning; 4th Revised edition edition. PHI Learning; 4th Revised edition edition

ESE-	Power Transmission, Distribution & Utilization	4(3-1)

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

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

Course outcome:

COURSE LEARNING OUTCOMES:

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

S. No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the concept of power Transmission and distribution.	Cognitive	3	1
2.	**ANALYZE** the power transmission and distribution systems.	Cognitive	4	2

3.	**DEMONSTRATE** the principles of transmission and distribution systems.	Psychomotor	3	4

Course Outline:

1. Introduction:

a. Circuit theory and analysis tenchniques
b. Real , reactive and apparent power relationship
c. Intoduction to MATLAB analysis and transformation technique

2. Power Transmission:

a. One-line diagram, choice of voltage and choice of AC/DC systems, introduction to HV, EHV and UHV systems.
b. Conductor Types, skin effect, Ferranti effect. Short, medium and long transmission lines, voltage regulation and line surges.
c. Line Supports, Sag and tension calculation, effect of wind pressure and ice loading, conductor vibration and use of dampers.
d. Insulators and Insulator material, string efficiency, corona effect. Introduction to HVDC transmission.

3. Power Distribution:

a. Distribution systems. Primary, secondary and tertiary voltages.
b. Radial and ring main systems, distribution transformer, Disadvantages and causes of low power factor, methods for improvement, application of shunt capacitors in distribution network.

4. Power Utilization:

a. Heating, Welding and load types: Electric heating, resistance, induction and dielectric heating, electric furnaces, microwave heating,
b. Electric welding, resistance welding and load types;domestic, indutrial

5. Fundamentals of Illumination Engineering:

a. Laws, units and terms used, requirements for good lighting, illumination schemes for various situations (street lighting, commercial/industrial lighting, stadium/flood/stage/spot lighting etc.)
b. Types of lamps, their working and relative merit, Building lighting design.

Practical:
Experiments related to Power Transmission, Distribution & Utilization will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Recommended Books:

1. M. V. Deshpande, “Elements of Electrical Power Station Design”, 2010, PHI Publishers
2. M. M. El Wakil, “Power Plant Technology”, McGraw Hill International Editions, Electrical and Mechanical Engineering Series.
3. Arche W. Culp “Principles of Energy Conversion”, Latest Edition. TuranGonen, “Electrical Power Distribution System”, CRC Press.
4. M. L. Anand, “A Text Book of Electrical Power”, Latest Edition
5. Arche W. Culp “Principles of Energy Conversion”, Latest Edition.
6. Turan Gonen, “Electrical Power Transmission System Engineering --- Analysis & Design”, John Wiely& Sons.
7. Electrical Transmission and Distribution Reference Book by Central Station Engineers, Westinghouse

ESE-	Petroleum and Gas Exploration	3(2-1)

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

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

Course outcome:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** various petroleum engineering concepts and operations	Cognitive	2	1

2.	**SOLVE** problems pertaining to the exploration and production processes	Cognitive	3	2
3.	**DEMONSTRATE** the basic principles and operations of petroleum and gas exploration	Psychomotor	3	4

Course Outline:

1. Historical over view of discovery and exploitation of petroleum and its products.
2. Physical and chemical properties of petroleum.
3. Introduction to petroleum geology.
4. Methods of exploration.
5. The sub-surface environment.
6. Generation and migration of petroleum.
7. Well-drilling and prediction.
8. Reservoir characterization.
9. Traps, sedimentary basins, reservoir production methods.
10. Production modeling and simulation.
11. Gas treating processes, process description of gas treating unit, review of liquid solvent treating of gases, process calculation for an amine contactor and combating degradable impurities in methyl, ethyl amine gas treating.

Practical:

Experiments related to Petroleum and Gas Exploration will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Suggested Readings:

1. Petroleum Production Systems by Michael J.
2. Petroleum engineering drilling and well completion by Carel Gatin.
3. A first course in Petroleum Technology by David A.T. Donobu, Karl R.Laug.

4. Geology of Petroleum by A.I. Levorsen.
5. Properties of petroleum fluids by William. D.
6. Drilling Engineering by Robert. F. Mitohell.

ESE-	I.C. Engines	3(2-1)

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

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

Course outcome:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**APPLY** the concepts of thermodynamic processes to IC Engines.	Cognitive	3	1
2.	**ANALYZE** the problems related to engine systems and performance	Cognitive	4	3
3.	**COMPREHEND** the environmental impacts of IC Engines.	Cognitive	2	7
4.	**INVESTIGATE** the performance of IC Engines	Psychomotor	3	4

Course outline:

1. Introduction:
   a. History of engine development ,engine cycles
   b. Principles of operation,types of engines

2. Principal parts of engine:
   a. Functions, construction,cylinder
   b. Cylinder heads,liner.crank case
   c. Piston .connecting rod,crank shaft,clutch ,flywheel
   d. Valves and their operation,valve mechanism

3. Fuels and combustion:
   a. Types of engine fuels
   b. Fuel tests and their significance

c. Gasoline tests, antiknock test,octane number,volatility of fuels
d. Reid vapour pressure Sulphur content, gum content ,heat values
e. Gasoline additives,engine emissions and their analysis

4. Fuel System:

a. Major components of fuel systems (petrol / diesel), carburettor,
b. Fuel injection pump, injector/nozzles, electronic fuel injection,
c. Governing system, trouble shooting, calibration of fuel injection pump.

5. Ignition system:

a. Types of ignition, spark, magneto and compression ignition,
b. Induction coils, distributor, spark plug
c. Contact-breaker points, condenser, trouble shooting.

6. Cooling system:

a. Types, principle of operation, parts of air/water cooling system,
b. Line diagram, radiator, thermostat, water pump, fan, engine heating
c. Repair and maintenance, types of coolants.

7. Lubrication system:

a. Types, principle of operation, components of lubrication systems
b. Line diagram, types of lubricants, trouble shooting.

8. Electrical System:

a. AC and DC voltage, alternator/dynamo, battery
b. Battery charging and maintenance, self-starter
c. Electrical gauges and controls, line diagram, repair and maintenance

9. Intake and exhaust system:

a. Air intake system, air cleaner, super charger, turbo charger, inter-cooling, and construction of intake and exhaust manifolds, mufflers, flue gases.

10. Clutch and Brakes:

a. Transmission, Differentials, Power take-off
b. Pulley drives, Power lift and hydraulic controls.

11. Engine Emissions and their control:

a. Types of emissions, sources of the emissions,
b. Pre-combustion and post-combustion emission controlling methods

12. Dual Fuelling of IC Engines:

a. Modern practices in automobiles
b. Dynamometer and engine diagnostics

Practical:

Experiments related to I.C. Engines will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. Single, R.K. 2004. Internal Combustion Engines. S.K. Katana & Sons. New Dehli, India.
2. Jain, S.C. and C.R. Rai. 2000. Farm Tractor Maintenance and Repair, Tata McGraw Hill Publishing Company Limited, New Delhi.
3. Halderman, J.C. and D. Mitchell. 2005. Automotive Engines: theory and servicing, 5th Ed. Pearson Prentice Hall, Singapore.
4. Promersberger and Bishop. 1996. Farm Power. Prentice Hall Inc. Englewood Cliffs, New Jersey. USA.
5. Paul, W.G., S. James.and E.J. Ziruys. 1995. Fundamentals of Internal Combustion Engines, 4th Ed. Oxford & IBH Publishing Company (Pvt) Ltd, New Dehli..

ESE-	RS & GIS for Renewable Energy Resources	3(2-1)

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

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

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Acquire** the knowledge of coordinate systems, projections and geo-referencing.	Cognitive	2	1
2.	**Analyze** and interpret satellite imaging for site selection	Cognitive	4	2
3.	**Demonstrate** the use RS & GIS software for	Psychomotor	3	4

	identifying potential zones to harness energy.			

Course outline:

1. Introduction

a. Introduction to Global positioning system (GPS),
b. Satellite imagery, Introduction to RS & GIS?, Example applications of RS & GIS
c. Coordinate systems and projections, geo-referencing and scale generalization

2. GIS

a. Raster and vector data set,
b. Use of GPS and DGPS,
c. Data import and export, Open existing tables, Creating new tables, Drawing objects on a map, Creating and using layouts.
d. Spatial interpolation and geo-station
e. Spatial data analysis, spatial statistics
f. Terrain analysis and assessment
g. Vector to raster and vice versa

3. RS

a. Satellite data acquisition
b. Image processing
c. Image interpretation
d. Site identification for solar system installation, wind energy set up and hydropower energy.

Practical:

Experiments related to RS & GIS for Renewable Energy Resources will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. DeMers, M.N., 2005. Fundamentals of geographic information systems, Wiley, Hoboken, N.J. ISBN: 0471451495. Shelf Number: 910.285 DEM

2. Longley, P, Goodchild, MF, Maguire, DJ, Rhind, W, 2005. Geographical information systems and science, 2nd edition, John Wiley, Chichester. ISBN: 047087001X. Shelf Reference: 910.285 LON.
3. Bhatta, B. 2008. Remote Sensing and GIS. Oxford University Press; 1 st edition (March 27, 2008)
4. Wegmann, M., Leutner, B., Dech, S. 2016. Remote Sensing and GIS for Ecologists: Using Open Source Software (Data in the Wild). Pelagic Publishing.
5. George P. Petropoulos. 2013. Remote Sensing of Energy Fluxes and Soil Moisture Content. CRC Press; 1 edition.
6. Keranen, K., Kolvoord, R. 2013. Making Spatial Decisions Using GIS and Remote Sensing: A Workbook. Esri Press; 1 edition

ESE-	Heating Ventilation and Air Conditioning Systems	4(3-1)

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

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

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**COMPREHEND** knowledge of the vapor compression and vapor absorption refrigeration systems, various refrigerants and their applications	Cognitive	2	1
2.	**APPLY** the fundamental concepts of air conditioning, its scope and applications to perform psychrometric analysis of air conditioning systems.	Cognitive	3	2
3.	**DESIGN** and select various HVAC components	Cognitive	5	3

4.	**ANALYZE** energy conservation strategies for HVAC systems by using modern tools	Cognitive	4	5

Course outline:

1. Introduction and types of cooling systems:

a. Definition and basic terminology
b. Refrigeration cycle,vapor compression cycle.COP
c. Introduction to pressure-enthalpy chart,types of refrigerants,air cycle refrigeration ,vapor absorption refrigeration and air conditioning,working principle of thermally driven cooling machines ,single, double and triple effect absorption chiller,adsorption chiller
d. Desiccant evaporative cooling,ejector cycle

2. Air-conditioning:

a. Indoor and outdoor air conditions
b. Comfort air conditions and comfort zoneindoors air quality, psychrometry,
c. Psychometric chart and psychometric properties
d. Central air conditioning system ,essential components of central air conditioning plant
e. Water chiller and water heater, air handling unit,chilled water and hot water re-circulating system,return air supply system.fresh air supply system and air mixture chamber
f. Supply fan, air dust cleaning and bacteria removal,air supply and air return terminals
g. Diffusers, dampers, grillers and registers

3. Air-conditioning system design:

a. CFM rating and tons of air conditioning of central air conditioning plant,cooling and heating loads
b. Calculation procedures, duct sizing and piping design,
c. Pumps and fans selection, air ventilation
d. Calculation of fresh air supply of multi-story buildings, air handling units for treatment of fresh and return,forced convection based air ventilator design

4. Cooling towers:

a. Types of cooling towers
b. Performance of cooling tower
c. Hydronic terminal units

5. Indoor air quality:

a. Dust and bacteria removal methods.

6. Alternative cooling techniques:

a. Thermo-electric, magnetocaloric,electrocaloric,
b. Thermo-accoustics, solar-assisted cooling systems

Practical:
Experiments related to Heating Ventilation and Air Conditioning Systems will be covered in the lab classes.

Teaching Methodology
- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. Circle, T. and N.E. Atlanta. 1997. ASHRAE, Handbook - Fundamentals, SI Edition, American Society of Heating, Refrigerating and Air-Conditioning Engineers. USA.
2. Duffie, J.A. and W.A. Beckman. 1991. Solar Engineering of Thermal Processes, 2nd Ed. John Wiley & Sons, USA.
3. Kreith, F. and J.F. Kreider. 1978. Principles of Solar Engineering, 2nd Ed. McGraw-Hill, New York.
4. Kreider, J.F. and F. Kreith. 1981. Solar Energy Handbook. 2nd ED. McGrawHill, New York USA.

ESE-	Energy Conservation and Auditing	3(2-1)

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

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

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

S. No.	CLO	Domain	Taxonomy level	PLO
1.	**CONSTRUCT** the energy flow diagram of an industry and identify the energy wasted.	Cognitive	3	2
2.	**SELECT** an appropriate energy conservation	Cognitive	4	2

	method to reduce the wastage of energy			
3.	**CARRY OUT** energy audit of an industry/organization	Psychomotor	3	5

Course outline:

1. Energy Conservation Approaches In Industries

a. Energy saving opportunities in electric motors, Benefits of Power factor improvement and its techniques-Shunt capacitor, Synchronous Condenser etc.
b. Effects of harmonics on – Motors, and remedies leading to energy conservation.
c. Energy conservation by Variable Speed Drives (VSD)
d. Methods and techniques of energy conservation in ventilation and air conditioners - compressors pumps, fans and blowers
e. Area Sealing, Insulating the Heating / cooling fluid pipes, automatic door closing- Air curtain, Thermostat /Control, Energy conservation in electric furnaces, ovens and boilers
f. Lighting techniques – Natural, Compact Fluorescent Lamps (CFL), Light Emitting Diodes (LED) lighting sources and fittings
g. Calculation and costing of proposed energy conservation measure, Depreciation cost, sinking fund method. Cost evaluation by Return On Investment (ROI) and pay back method, Risk Analysis, Case study

2. Energy Auditing

a. Energy audit and its benefits
b. Energy flow diagram
c. Preliminary, Detailed energy audit. Methodology of preliminary energy audit and detailed energy audit (Pre audit, Audit and Post audit), ISO 50001
d. Energy audit report
e. Introduction to tools rquired for energy auditing. Required tools for conducting energy audit (Power Analyzer, Combustion analyzer, fuel efficiency monitor, thermometer-contact infrared, pitot tube and manometer, water flowmeter, leak detector, tachometer and lux meter)

Practical:

Experiments related to Energy Conservation and Auditing will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments

- Guest Speaker
- Field Visits
- Report Writing

Assessment:
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text books:
1. Electric Energy Generation, Utilisation and Conservation by Sivaganaraju, S Pearson, New Delhi, 2012
2. Energy Management Handbook by Wayne C. Turner
3. Energy Management by Paul O Callaghan, Mcgraw Hill, New Delhi

ESE-	**Bioenergy Engineering**	**3(2-1)**

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

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

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the key concepts of biomass to energy conversion technologies along with region wise biomass resource availability	Cognitive	2	1
2.	**RELATE** availability of biomass feedstock in different areas of Pakistan, weather conditions and their potential attributes to bio-energy production.	Cognitive	3	2
3.	**CREATE** mass and energy balances for various biomass to energy conversion case studies for process design	Cognitive	6	3

4.	**DEMONSTRATE** individually the optimal operation of anaerobic digester and biomass gasifier, analysis of gas compositions and gas up-gradation	Psychomotor	3	5

Course outline:

1. Introduction to Biomass Resources and Technologies

a. Biomass Resources in Pakistan (Biomass Atlas)
b. Modes of Biomass utilization for Energy
c. Routes of Biomass Conversion Processes and biofuels production technologies
d. History and Success Stories of Energy from Biomass

2. Characteristics of Biomass Fuels

a. Fuel analyses
b. Sample preparation
c. Techniques for characterization and chemical analyses of solid, liquid and gas samples
d. Relevance of feed properties for anaerobic digestion and thermochemical processes

3. Biomass Feedstock preparation

a. Biomass feedstock dewatering and drying techniques, moisture content and conversion requirements, methods
b. Size reduction: Fundamentals, Steam explosion
c. Densification: Types of Densification Devices, Properties of Densified Fuels
d. Separation: Municipal solid waste, Virgin biomass, Extraction

4. Thermochemical Conversion

a. Pyrolysis: Torrefaction, Slow and Fast Pyrolysis, Charcoal Production.
b. Gasification: Fundamentals, Fixed bed Gasifiers
c. Technical and operations problems with Fixed bed Gasifiers, Fluidized bed Gasifiers, Entrained Bed Gasifiers
d. Comparison between Fixed bed and Fluidized bed Gasifiers, Gas Treatment, Equilibrium and Kinetic Considerations.

5. Anaerobic-aerobic digestion

a. History of biomass digestion
b. Various types of biogas plants.
c. Kinetics and mechanism- High rate digesters for industrial waste water treatment.

d. Design, installation, operation and management of fixed dome and floating drum biogas plants, Power generation from biogas plants
e. Purification of biogas for grid quality methane/natural gas
f. Digester effluent utilization strategies

6. Combined heat and power production from Biomass

a. Concept of CHP in energy production
b. Poly-generation process (heat, electricity and chemical production)
c. IGCC without and with carbon capture
d. Drawing up of mass and energy balances
e. Evaluation of the techno- and eco-efficiency
f. Economic evaluation/preparation of business plan (Group exercise)

Practical:

Experiments related to Bioenergy Engineering will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. Mital, K.M. 2007. Biogas Systems: Principles and Applications. New Age International publishers Pvt. Ltd. New Dehli India.
2. A.V. Bridgwater: Advances in Thermochemical Biomass Conversion, Springer, 2008
3. Nijaguna, B.T. 2006. Biogas Technology. Reprint Ed. New Age International publishers Pvt. Ltd. New Dehli India.
4. Donald L. Klass: Biomass for Renewable Energy, Fuels, and Chemicals, Academic Press, 1998
5. H.A.M Knoef: Handbook Biomass Gasification, BTG, 2005
6. Prabir Basu: Biomass Gasification and Pyrolysis: practical design and theory, 2010

ESENG-	**Project & Report-I**	**3(0-3)**

Objectives:
To provide experience of working as part of a project team of 4 to 6 in a situation close to that which might be found in an industrial or commercial setting. To apply knowledge and skills, at the forefront of the renewable energy discipline, obtained from taught modules and independent learning to a real engineering situation at a professional level and as part of a team effort. To integrate knowledge gained in several areas of the degree course. To encourage the use of initiative, imagination and creativity applied in the context of a team effort. The project topic is product design orientated.

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

Suggested Readings:
1. Awan, J. A. 2004. Technical writing. University of Agriculture press, Faisalabad

ESE-	Power Electronics	3(2-1)

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

Credit Hours:
Theory = **2.0**
Practical = **1.0**
Total = 3**.0**

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

S. No.	CLO	Domain	Taxonomy level	PLO
1.	UNDERSTAND the fundamentals of power semiconductor devices	Cognitive	1	1
2.	UNDERSTAND the basic principles of uncontrolled and controlled rectifiers and their ANALYSIS under different loading conditions	Cognitive	4	2

3.	ANALYZE and DESIGN converters for operation in steady state Continuous and Discontinuous Conduction Mode	Cognitive	4	3
4.	APPLY the knowledge of converter to DESIGN in lab environment working individually and as a group	Psychomotor	3	5

Course outline:

1. Introduction
- a. Principles of power electronics
- b. Recent advancement in Power Electronics and its Application
- c. Converter circuit components and their effects
- d. Converter control aspects

2. Power Electronic Devices
- a. Power Diodes
- b. Freewheeling diodes
- c. The Silicon-Controlled Rectifier (SCR)
- d. The Diac and Triac
- e. Diodes with RC and RL, LC and RLC loads.
- f. Power Transistors
- g. The Unijunction Transistor (UJT)
- h. The Programmable Unijunction Transistor (PUT)
- i. Types of thyristers
- j. Triggering devices
- k. Construction
- l. Characteristics, operations, losses, ratings,
- m. Control and protection of thyristors

3. Power Converters Rectifiers
- a. Static switches
- b. Solid state relays
- c. Single phase uncontrolled rectifiers
- d. Single phase semi-controlled rectifiers
- e. Single phase Fully controlled rectifiers
- f. Three-phase uncontrolled rectifiers
- g. Three-phase semi controlled rectifiers
- h. Three-phase fully controlled rectifiers

4. Inverters
- a. Single-phase inverters
- b. Three-phase inverters

5. AC-AC Converters
- a. Single-phase-to-single-phase cycloconveters
- b. Matrix converters

c. AC voltage regulators

6. DC-DC converters

a. Buck converter
b. Boost converter
c. Buck-boost converters
d. Isolated converters
e. Forward converters
f. Flyback converters

7. Power Electronics Applications

a. Switching mode power supplies
b. Power electronics control of Electrical Machines
c. Power system utilities

Practical:

Experiments related to Power Electronics will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and reference books:

1. Ned Mohan, William P. Robbins and Tore M. Undeland, "Power Electronics: Converters, Applications and Design," Media Enhanced, John Wiley & Sons, 4th revised edition (2017)
2. Robert W. Erickson and Dragan Maksimovic, "Fundamentals of Power Electronics," Springer, 2nd Edition (2004)
3. Muhammad H. Rashid "Power Electronics: Circuits, Devices & Applications" Prentice Hall, 4th Edition (2013).
4. Daniel Hart, "Power Electronics," McGraw-Hill, 1st Edition (2011).

ESE-	Energy Economics, Policy and Management	3(3-0)

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

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

Course outcome:

COURSE LEARNING OUTCOMES:

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

S. No.	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the Pakistan's current energy and environmental situation and policies	Cognitive	2	7
2.	**APPLY** the basics of energy economic and project management	Cognitive	3	1
3.	**ANALYZE** the sustainability of energy projects (case study)	Cognitive	4	7

Course outline:

1. Pakistan's Energy and Environmental Profile

a. Pakistan's energy supply-demand situation
b. Pakistan's energy related greenhouse gas (GHG) emissions
c. Impact of energy on economy, development and environment
d. Energy for sustainable development and need for use of new and renewable energy sources
e. Energy sources and overall energy demand and availability
f. Energy consumption in various sectors and its changing pattern
g. Exponential increase in energy consumption and projected future demands

2. Energy Economics and Management

a. Basics of supply, demand and price formation in competitive markets
b. Energy demand: short run and long run price and income elasticities
c. Introduction to single variate and multi variate regression analysis,
d. Cost of power plant, structure of power tariffs
e. Concept and theory of management, methods and processes of management,
f. Introduction to smart grid (On- and Off- grid system)
g. Introduction to project management,
h. Energy contracts & preparation of PCs,
i. Regulatory bodies, NEPRA, OGRA, PPIB
j. Net-metering, Feed-in-tariff policy
k. Financial management and introduction to accounting, auditing, cash flow terms,

l. Estimation of economic and financial rates of return, prices, wages, profit and interest

3. Pakistan's Energy and Environmental policies

a. Overview of Pakistan's oil, gas and power policies
b. Sustainability analysis of energy policies and reasons for failure of energy policies
c. Sustainability analysis of energy projects
d. Energy diplomacy, Energy Security, Energy diversity
e. Depletion of energy sources and their impact on economies of countries and on international relations
f. International Energy and Environmental treaties (Rio, Montreal, Kyoto, Paris)
g. Pakistan's Intended *Nationally Determined Contributions* (INDCs).
h. Energy investments under China-Pakistan Economic Corridor.
i. Impacts of coal related investments under CPEC on energy and environment profile of Pakistan

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. Ayres, R.U. and E.H. Edward. Crossing the Energy Divide: Moving from Fossil Fuel Dependence to a Clean-Energy Future.
2. Bern, G. Investing in Energy: A Primer on the Economics of the Energy Industry. Wiley and Sons. USA.
3. Energy Management Handbook by Wayne C. Turner
4. Energy Management by Paul O Callaghan, Mcgraw Hill, New Delhi

ESENG-	Project & Report-II	3(0-3)

Objective:

To provide experience of working as part of a project team of 4 to 6 in a situation close to that which might be found in an industrial or commercial setting. To apply knowledge and skills, at the forefront of the renewable energy discipline, obtained from taught modules and independent learning to a real engineering situation at a professional level and as part of a team

effort. To integrate knowledge gained in several areas of the degree course. To encourage the use of initiative, imagination and creativity applied in the context of a team effort. The project topic is product design orientated.

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

Suggested Readings:
1. Awan, J. A. 2004. Technical writing. University of Agriculture press, Faisalabad.

List of Contents of Engineering Elective Courses

ESE-	Renewable Energy Systems	3(2-1)

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

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

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**ACQUIRE** the knowledge of renewable energy resources and renewable energy conversion systems	Cognitive	2	1
2.	**ANALYZE** and **EVALUATE** the renewable energy conversion systems and problems associated with them	Cognitive	4	2
3.	**DEMONSTRATE** different renewable energy systems	Psychomotor	3	3

Course outline:

1. **Introduction**
   a. Energy scenario of Pakistan and the world
   b. Energy crisis
   c. Environmental hazards
   d. Opportunities for renewable energy utilization
2. **Solar energy**
   a. Solar thermal collectors and applications
   b. Solar photovoltaic cells and modules
   c. Solar PV system applications
   d. Solar dryers
   e. Solar heating and cooling systems
3. **Wind energy**
   a. Wind characteristics and resources
   b. Fundamental principles
   c. basic parts and aerodynamics of wind turbines/ plants
   d. Applications of wind power
4. **Hydropower**
   a. Introduction to Hydropower
   b. Potential in Pakistan
   c. Components and applications
   d. Design of small low head turbines
5. **Biomass Energy**
   a. Biomass resources in Pakistan
   b. Biomass to bioenergy potential in Pakistan
   c. Biomass energy conversion systems
   d. Biomass energy applications
   e. Design of biogas plant
   f. Design of compost bits for gas generations
6. **Ocean Energy**
   a. Basic Tidal characteristics and resource
   b. Tidal power generation
   c. Wave energy resource and conversion
   d. Ocean thermal energy conversion
7. **Geothermal energy**
   a. Geothermal resources and power generation
8. **Hybrid energy systems**
   a. Design and sizing of renewable energy systems
   b. Renewable energy storage and transmission
   c. Application of renewable energy in agriculture
   d. Design of solar operated drip irrigation system
   e. Economic analysis
   f. Social and environmental aspects
   g. Simulation of renewable energy systems
   h. Renewable energy legislation and regulations

i. Future of renewable energy

Practical:
Experiments related to Renewable Energy Systems will be covered in the lab classes.

Teaching Methodology
- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. Renewable Energy Resources 2nd/Ed, Twidell J, 2006, 9780419253303
2. Volker Quaschning, Earthscan, 2000, Renewable Energy Conversion, Transmission, and Storage. Bent Sorensen Academic Press.
3. M. Aslam Uqaili and Khanji Harijan, 2000, Energy, Environment and Sustainable Development. Springer Verlag.
4. Fundamentals Of Renewable Energy Resources And Technology, By Kumar E S Isbn: 9789327235746. 2013
5. Environmental Impacts Of Renewable Energy By Spellman F R Isbn: '9781482249460. 2015
6. Bioenergy Technology And Engineering By Bailiang Isbn: E5778
7. Geothermal Reservoir Engineering 2nd/Ed, Grant M A, 2011, 9780123838803
8. Introduction to Photovoltaic System Design, Balfour J, 2013, 9781449624675
9. Solar Photovoltaic Fundamentals, Technologies and Applications 2nd/Ed, Solanki C S, 2013, 9788120343863
10. Sustainable Bioenergy Production, Wang L, 2014, 9781466505520
11. Sustainable Energy Solutions In Agriculture, Jochen B, 2014, 9781138001183
12. Wind Energy: Renewable Energy and The Environment 2nd/Ed, Nelson V, 2014, 9781466581593

ESE-	Hydrogen and Fuel Cells	3(2-1)

Contact Hours:
Theory = 32

Credit Hours:
Theory = **2.0**

Practical = 48 Practical = **1.0**
Total = 80 Total = **3.0**

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**ACQUIRE** the knowledge of hydrogen systems, storage, production and its application in fuel cells.	Cognitive	2	1
2.	**ANALYSE** appropriate hydrogen energy systems for use with fuel cell systems	Cognitive	4	2
3.	**DEMONSTRATE** the principle of operation of hydrogen energy systems and fuel cell	Psychomotor	3	4

Contents:

1. Fuel-cell technologies, possible fuels, and their applications
2. Hydrogen as Future Energy Carrier.
3. Hydrogen Fuel Cell Engines and Technologies,
4. Hydrogen Properties, thermal, electrolytic,
5. Photolytic processes of hydrogen decomposition.
6. Hydrocarbon Decomposition water decomposition.
7. Hydrogen Distribution, Hydrogen Storage.
8. Hydrogen Use in Internal Combustion Engines; Hydrogen feeding system, air feeding system, thermal management system, Integrated Fuel Cell System.
9. Hydrogen feedstock and basics of its reforming; Fuel Cell Principles;
10. Introduction to fuel cell types, basic principles; Polarization curve, Fuel cell thermodynamics;
11. Fuel cell reaction kinetics; Charge transfer in fuel cells; Mass transport in fuel cells;
12. Fuel cell characterization, Fuel reforming technologies, types of fuel reformers,
13. Overview of fuel cell types; Proton exchange membrane and solid oxide fuel cell materials

14. Overview of fuel cell systems.

Practical:
Experiments related to Hydrogen and Fuel Cells will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Suggested Readings:

1. Corbo, P., • F. Migliardini, and O, Veneri, (2011) Hydrogen Fuel Cells for Road Vehicles, Springer-Verlag London Limited
2. Stolten, D. and B. Emonts, (2012) Fuel Cell Science and Engineering, Wiley-VCH Verlag & Co. KGaA
3. Bejan, A. Advanced Engineering Thermodynamics. Wiley Int. Ed. 1988
4. Heywood, J. B.: Internal Combustion Engine Fundamentals. Mc Graw Hill 1988. ISBN 0-07-028637-X
5. Hoogers G., Fuel Cell Technology Handbook. CRC Press and SAE International 2002 ISBN: 978-0-7680-0706-0
6. Larminie J., Dicks A., Fuel cell systems explained. 2nd ed. Wiley, 2003 ISBN: 0-470-84857-X
7. Principles of Fuel Cells. Xianguo Li. Taylor & Francis Group, 2006.
8. Fuel Cell Systems. Leo J.M.J. Blomen, Michael N. Mugerwa. Plenum Press, New York, 1993 SAE publications 1999-2006

ESE-	Control Systems	3(2-1)

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

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

Course outcome:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**CONSTRUCT** mathematical model using input/output differential equations, Transfer Functions and State Space for Linear Time Invariant electrical and mechanical systems.	Cognitive	3	2
2.	**ANALYZE** the stability of Linear Time Invariant complex engineering systems using Routh's Criteria, Root Locus, Bode plots and State Space analysis.	Cognitive	4	2
3.	Design a compensator to achieve desired closed loop response for a system using, Root Locus, Bode plots and State Space.	Cognitive	5	3
4	**INVESTIGATE** the computational models of control systems using modern tools	Cognitive	2	5
5	**DEMONSTRATE** the application of control systems performing various experiments	Psychomotor	3	4

Course outline:

1. Modeling of electrical, mechanical and biological control systems.
2. Open and closed-loop systems,
3. Block diagrams.
4. Second order systems.
5. Step and impulse response.
6. Performance criteria.
7. Steady state error. S
8. ensitivity, s-plane system stability.
9. Analysis and design with the root loci method.
10. Frequency domain analysis,
11. Bode plots, Nyquist criterion, gain and phase margins, Nichols charts.

12. State-space method, state equations, flow graphs, stability, compensation techniques.
13. Simulation and Controller design using computer programs such as linear quadratic guassian, linear quadratic regulator, h-controller etc.

Practical:
Experiments related to Control Systems will be covered in the lab classes.

Teaching Methodology
- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Recommended books:
1. Steffani, Savant, Shahian and Hostetter, "Design of Feedback Control Systems" 4th Edition, Saunders College Publications.
2. Katsushiko, Ogata, "Modern Control Engineering," McGraw-Hill, `5th Edition
3. R. C. Dorf and R. H. Bishop, "Modern Control Systems," 12th Edition
4. B. C. Kuo, "Automatic Control Systems" 7th Edition

ESE-	Geothermal and Tidal Energy	3(3-0)

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

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

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the knowledge of geothermal energy, tidal and wave energy conversion systems	Cognitive	2	1

2.	**ANALYZE** the issues and problems for successful exploration of geothermal and tidal energy.	Cognitive	4	2
3.	**DEMONSTRATE** individually the worldwide success stories and case studies for geothermal and tidal energy generation.	Psychomotor	3	4

Course outline:

1. Geology of Geothermal Regions
   a. Exploration Strategies and Techniques Principles
   b. Heat source systems for ambient air utilization
   c. Heat source systems for shallow geothermal utilization

2. Geothermal well drilling
   a. Design of down hole part
   b. Up hole part system
   c. District heating system
   d. Environmental analysis of geothermal energy
   e. Case study related to geothermal energy

3. Steam Power Plants
   a. Single and double flash steam power plants
   b. Binary cycle power plants
   c. Advanced geothermal energy conversion systems,
   d. Exergy analysis applied to geothermal power systems

4. Tidal and wave energy
   a. Tidal and wave energy conversion systems

Teaching Methodology
- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:
1. Pimental, D. and R. DiPippo. 2008. Geothermal Power Plants, 2nd Ed. Elsevier. USA.

2. Gupta, H. and S. Roy. 2007. Geothermal Energy – An Alternative Resource for the 21st Century, 1st Ed. Elsevier, USA.
3. Tabak, J. 2009. Solar and Geothermal Energy 1st Ed. Facts On File.
4. Charlier, R.H. and W.Finkl. 2009. Ocean Energy Tide and Tidal Power. 1st Ed. Springer.
5. Brooke, J. 2003. Wave Energy Conversion. 1st Ed. Vol- 6. Elsevier Ocean engineering.

ESE-	Nanotechnology and Energy	3(3-0)

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

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

Course outcome:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the concepts of Nanoscience and Nanotechnology	Cognitive	2	1
2.	**DEVELOP** techniques for fabrication and characterization methods	Cognitive	3	2
3.	**SYNTHESIZE** various nanomaterials as building blocks of Nanotechnology	Psychomotor	3	3

Course outline:
1. Introduction to Nanotechnology and Nano ,
2. Characteristics of Nano material;
3. Crystal structure and geometry,
4. Common crystal structures,
5. Mechanical properties and strengthening mechanisms,
6. Microstructure and its control in engineering materials,
7. Band theory of metals and non-metals;

8. Electrical properties of materials,
9. Cnts and quantum dots, super capacitors,
10. Lithium ions battery,
11. Hydrogen storage,
12. Nano catalyst for optimized fuel production,
13. Dye sensitized solar cell, quantum dot solar cell,
14. Semi-conducting Nano-materials and photo catalyst,
15. Metal oxides and sulfides for hydrogen production,
16. Limitation of existing photo catalyst,
17. Introduction conducting polymers, organic light emitting diodes,
18. Conducting polymers solar cells.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Suggested Readings:

1. Wilson, M., K. kannangara, B.Raguse, M.Simmon. 2002. Nano technology: basic Science and emerging technologies, Chapman and Hall/CRC.
2. Garcia-Martinez, J. 2010. Nanotechnology for energy challenge, Wiley-VCH.
3. Somorjai, G.A., H.Frei, J.Y. Park 2009. Advancing the frontries in nanocatalyst, biointerfaces and renewable energy conversion by innovations of surface techniques, J. Am. Chem. Soc., 131,16589.
4. Rohrer, G. S., 2001. Structure and Bonding in Crystalline Materials, CambridgeUniversity Press, Cambridge, UK.
5. Nalwa, H.S(Editor). 2000. Handbook of Nanostructured Materials and Nanotechnology', Volume 3, 'Electrical Properties', Academic Press, New York, USA.

ESE-	Machine Design	3(3-0)

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

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

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**Explain** the application of design standards and the importance of dimensional parameters in manufacturing aspects of mechanical design	Cognitive	2	1
2.	**Analyze** different types of structural joints, power transmitting shafts and mechanical springs	Cognitive	4	3
3.	**Present** the design aspects effectively through oral presentation	Affective	2	10

Course outline:

1. **Introduction**
   a. Design philosophy
   b. Types of design
2. **Mechanical behaviour of materials**
   a. Concepts of stress and strain
   b. Different types of stress and strain in a machine element
   c. Stress-strain diagram
   d. Actual and permissible stresses
   e. Factor of safety
3. **Design of keys and coupling**
   a. Basic concepts
   b. Methodology
4. **Design of Riveted joint, Welded joints, Bolted joints**
   a. Basic concepts
   b. Methodology
5. **Design of Springs, Shafts**
   a. Basic concepts
   b. Methodology
6. **Metal fits and tolerances and Design Standards**
   a. Basic concepts of tolerance
   b. Types of fits
   c. ISO standard fits charts
7. **Spur, Helical, Bevel and Worm Gears**
   a. Stress analysis on gear teeth
   b. Power transmission by the gears
8. **Design of Flywheels**

a. Concepts of designing flywheels for different requirements

9. Selection of bearings

a. Selection procedures of sliding contact bearings and rolling contact bearings

10. Design of Brake / Clutches

a. Different types of clutches and designing concepts
b. Different types of brakes and designing concepts

11. Selection of Standard Machine Elements

a. Selection of flat belts, V belts, chain drive and rope drives
b. Cams: Types of Cams & Followers, Follower Motion Schemes, Graphical Disk Cam Profile Design, Pressure Angle, Design Limitations
c. Governors: Types of Governors, Centrifugal Governors, Porter Governors, Parallel Governors, Spring Loaded Governors

Practical:

Experiments related to Machine Design will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. R. L. Mott ,Machine Elements in Mechanical Design, Pearson.
2. R. L. Norton, Design of Machinery, McGraw-Hill Education.
3. R. S. Khurmi and J. K. Gupta, A Textbook of Machine Design, Eurasia Publishing.
4. R. G. Budynas and K. J. Nisbett, Shigley's Mechanical Engineering Design, McGraw-Hill Education.

ESE-	Clean Coal Technology	3(2-1)

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

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

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** fundamental knowledge of clean coal technologies in producing accessible energy	Cognitive	2	1
2.	**APPLY** concepts of clean coal conversion technologies beneficial for exploiting the vast coal reserves in the country	Cognitive	3	2
3.	**ANALYZE** the case studies of clean energy generation from coal	Cognitive	4	2
4.	**DEMONSTRATE** individually operation of coal gasifier along with possible integration in FT synthesis	Psychomotor	3	4

Course outline:

1. Introduction to Clean Coal Technologies

a. Role of coal in the overall energy situation.
b. History of energy production from coal
c. Indigenous coal reserves
d. Recent advances in clean energy generation from coal

2. Coal Preparation for clean energy generation

a. Coal preparation methods including fine coal treatment.
b. Properties of coal and impurities in relation to preparation (emphasis on Thar coal)
c. Wash ability studies and evaluation of coal for different uses
d. Breaking and crushing; screening, wet concentration methods of coarse coal; wet concentration methods of fine coal
e. Status & scope of coal preparation by flotation
f. Dust collection in coal processing and handling

3. Clean coal gasification

a. Coal gasification basics/types
b. Coal gasifier designs/Reaction kinetics

c. Direct blowing & reverse blowing concepts
d. Air separation and gas cleanup
e. Syngas cleanup/ CO2 capture for CCS.

4. Underground Coal Gasification (UCG)

a. Technology Description
b. Geological aspects in UCG/ coal seam, overburden and water table
c. Thar coal UCG case study
d. Process flow diagrams
e. Channel formation b/w injection & production wells
f. Process parameters/Coal & Rock properties
g. Economics of UCG

5. Direct coal liquefaction

a. Process description
b. Process parameters & flow sheet diagrams
c. Single stage & two stage liquefaction
d. DCL catalytic reactors/ overview
e. Commercial Plants
f. Environmental considerations

6. Indirect coal liquefaction (Fischer Tropsch Process)

a. Process Description/ Process Flow diagrams
b. FT Process/ Reaction mechanism & kinetics
c. FT process parameters
d. Catalyst Preparation & Characterization
e. FT Reactor core concepts/Process control
f. Energy analysis/ Heat exchanger network optimization in FT synthesis
g. Products refining

7. Integrated gasification combined cycle: IGCC

a. Process description
b. Thermodynamic cycle of IGCC
c. Development of process flow diagram
d. CO2 pre combustion capture & storage
e. Energy requirements

Practical:

Experiments related to Clean Coal Technology will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits

- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. Bruce G. Miller (2010) Clean Coal Engineering Technology (ISBN: 978-1-85617-710-8)
2. Brian F. Towler, David Bell, and Maohong Fan (2010) Coal Gasification and Its Applications (ISBN: 978-0-8155-2049-8)
3. Stephen A. Rackley (2017) Carbon Capture and Storage, 2nd Edition (ISBN:9780128120422)
4. Ting Wang Gary Stiegel (2016) Integrated Gasification Combined Cycle (IGCC) Technologies (ISBN: 9780081001851)

ESE-	Fuels and Combustion	3(2-1)

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

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

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**ACQUIRE** the basic knowledge of fuels and combustion characteristics.	Cognitive	2	1
2.	**SOLVE** the application problems related to the chemical thermodynamics and chemical kinetics of combustion processes of variety of fuels.	Cognitive	4	2
3.	**COMPREHEND** the environmental impact of combustion processes of variety of fuels.	Cognitive	2	7
4	**INVESTIGATE** the performance of various	Psychomotor	3	4

	fuels and combustion processes			

Course outline:

1. Fuels

a. Solid, liquid and gaseous fuels,
b. Production, present scenario and consumption pattern of fuels Fundamental definitions, properties and various measurements,
c. Coal classification, composition and basis,
d. Coal mining, Coal preparation and washing,
e. Combustion of coal and coke making,
f. Exploration of crude petroleum,
g. Evaluation of crude, Distillation,
h. Secondary processing, Refinery equipments,
i. Natural gas and LPG, Producer gas, Other fuel gases

2. Chemical Thermodynamics And Flame Temperatures

a. Heats of reaction and formation,
b. Free energy and the equilibrium constants,
c. Flame temperature calculations,
d. Sub- and supersonic combustion thermodynamics,
e. Combustion burners, Combustion furnaces.
f. Calculation of calorific value of fuels,
g. Combustion air calculation

3. Chemical Kinetics

a. Rates of reactions and their temperature dependence,
b. Simultaneous interdependent reactions,
c. Chain reactions, Pseudo-first-order reactions and the" fall-off " range,
d. The partial equilibrium assumption, Chemical kinetics of large reaction mechanisms.

4. Flame Phenomena In Premixed Combustible Gases

a. Laminar flame structure and laminar flame speed.
b. Stability limits of laminar flames.
c. Flame propagation through stratified combustible mixtures.
d. Turbulent reacting flows and turbulent flames.
e. Stirred reactor theory. Flame stabilization in high-velocity streams.
f. Combustion in small volumes.

5. Detonation

a. Introduction to detonation phenomena.
b. Hugoniot relations and the hydrodynamic theory of detonations.
c. The ZND structure of detonation wave.

d. The structure of the cellular detonation front and other detonation phenomena parameters. Detonations in nongaseous media

6. Diffusion Flames

a. Gaseous fuel jets, Burning of condensed phases,
b. Burning of droplet clouds,
c. Burning in convective atmospheres

7. Ignition

a. Chain spontaneous ignition,
b. Thermal spontaneous ignition,
c. Forced ignition, Other ignition concepts

8. Environmental Combustion Considerations

a. The nature of photochemical smog, Formation and reduction of nitrogen oxides,
b. SOx emissions,
c. Particulate formation,
d. Stratospheric ozone

9. Combustion Of Nonvolatile Fuels

a. Carbon char, soot, and metal combustion,
b. Metal combustion thermodynamics,
c. Diffusional kinetics,
d. Diffusion-controlled burning rate,
e. Diffusion-controlled burning rate,
f. Soot oxidation

Practical:

Experiments related to Fuels and Combustion will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text books and Reference:

1. Combustion by Irvin Glassman.
2. Principles of Combustion by Kenneth Kuan-yun Kuo.
3. An Introduction to Combustion by Stephen Tums.
4. Combustion Processes in Propulsion by Gabriel Roy.

ESE-	Electrical Machines	3(2-1)

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

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

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**APPLY** the concepts of magnetic fields to understand the basic principles of AC and DC machines	Cognitive	3	2
2.	**COMPUTE** the various power and torque parameters of AC and DC machines and their equivalent circuits	Cognitive	4	2
3.	**DEMONSTRATE** the working principle and power and torque parameters of AC and DC machines.	Psycomotor	3	4

Course outline:

1. **Introduction to Electrical Machinery Principles:**
   a. Magnetic Field and Circuits,
   b. Magnetization curves Characteristics of hard and soft magnetic materials, losses.
2. **Transformers:**
   a. Ideal Transformer,
   b. Single Phase transformer:
   c. Operation and Equivalent Circuit,
   d. auto-transformer.
3. **DC Machinery fundamentals:**
   a. Basics, loop rotating between pole faces,
   b. Commutation,
   c. Windings,
   d. Armature reaction,
   e. Induced Voltage and torque equation.
   f. Power flow and losses,

g. Types of DC motors,
h. Permanent magnet DC motors.

4. **AC Machinery fundamentals:**
   a. Rotating Magnetic Field,
   b. Magnetomotive force and flux distribution,
   c. Induced Voltage and Torque, Windings, Power Flow and Losses.

5. Introduction to Induction Machines.
   a. Special Purpose Motors:
   b. Introduction to Single phase Induction Motors,
   c. Switched Reluctance motors,
   d. Hysteresis motors,
   e. Stepper, brushless DC motors.

Practical:
Experiments related to Electrical Machines will be covered in the lab classes.

Teaching Methodology
- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Recommended books:

1. Stephen J. Chapman, "Electric Machinery Fundamentals", McGraw-Hill. (Latest Edition)
2. Fitzgerald, Kingsley and Umans, "Electric Machinery", McGraw-Hill. (Latest Edition)
3. Hindmarsh, "Electrical Machines", McGraw-Hill. (Latest Edition)
4. Theodore Wildi “Electrial Machines, Drives, and Power Systems

ESE-	**Dynamics and Mechanisms of Machinery**	**3(3-0)**

Contact Hours:		**Credit Hours:**	
Theory	= 48	Theory	= **3.0**
Practical	= 00	Practical	= 0**.0**
Total	= 48	Total	= 3**.0**

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the concepts of mechanics for the design of machine elements.	Cognitive	2	1
2.	**CALCULATE** the kinematic characteristics of mechanisms such as linkages, cams, gears, governors and unbalance masses.	Cognitive	3	2
3.	**RELATE** analytical and/or graphical solutions to complex engineering problems in various machines and mechanisms.	Cognitive	4	3
4.	**ANALYZE** the physical parameters involved in natural frequency and system response to free and forced or impulse inputs to one/two degrees of freedom.	Cognitive	4	2

Course outline:

1. Introduction to Mechanisms

a. Machine & Mechanisms,
b. Mechanism Terminology,
c. Kinematic Diagram,
d. Kinematic Inversion,
e. Four Bar Mechanism,
f. Slider Crank Mechanism,
g. Techniques of Mechanism Analysis

2. Vector, Position and Displacement Analysis

a. Motion, Vectors,
b. Analytical Vector Methods Applied to the Displacement Analysis of Planar Linkages, Graphical Analysis,
c. Complex-Number Methods Applied to the Displacement Analysis of Linkages,
d. Spatial (Three-Dimensional) Linkages,
e. Computer-Implemented Numerical Methods of Position Analysis

3. Velocity Analysis of Mechanisms

a. Average Speed in Mechanize Mechanism,
b. Velocity of a Point in Mechanize Mechanism,
c. Angular Velocity in Mechanize Mechanism,
d. Motion of a Rigid Body about a Fixed Axis (Without Translation),
e. Moving Coordinate Systems and Relative Velocity,
f. Application of Analytical Vector and Matrix Methods to Linkages,
g. Four-Bar Linkage, Complex-Number Methods Applied to Velocity Analysis

4. Acceleration Analysis of Mechanisms

a. Planar Motion, Spatial Motion,
b. Relative Acceleration,
c. Analysis of a Four-Bar Linkage by Analytical Vector Methods,
d. Acceleration Analysis, Position Analysis,
e. The Acceleration Polygon,
f. Graphical Analysis of the Four-Bar Linkage,
g. An Analytical Solution Based on the Acceleration Polygon,
h. Graphical Analysis of Sliding Contact Linkages,
i. Trial Solution Method Applied to Linkage Acceleration Analysis,
j. Spatial Linkages, Acceleration Analysis of an RSSR

5. Design & Development

a. Mechanism Design,Time Ratio, Timing Charts,
b. Design of Slider Crank Mechanism,
c. Design of Crank Shaper Mechanism,
d. Mechanism to Move a Link Between Two Positions

6. Mechanical Vibrations

a. Fundamentals of Vibrations,
b. Degrees of Freedom
c. Discrete and Continuous Systems, SHM,
d. Vibration Analysis Procedure

7. Single Degree of Freedom Systems - Free Vibratory Systems

a. Newton's Method, Energy Method
b. Viscously Damped Free Vibration
c. Logarithmic Decrement, Springs and dampers in Combination

8. Single Degree of Freedom Systems – Forced Vibratory Systems

a. Forced Harmonic Vibration, Rotating Unbalance
b. Base Excitation, Vibration Isolation, Energy Dissipation by Damping
c. Whirling of Rotating shafts

9. Transient Vibration

a. Impulse Response Function,
b. Response to an Arbitrary Input

10. Systems with Two Degrees of Freedom

a. The Normal Mode Analysis, Free Vibration Analysis of an Undamped Systems
b. Coordinate Coupling, Free Vibration Analysis of Damped systems
c. Forced Harmonic Vibration of an Undamped Systems
d. Forced Harmonic Vibration of Damped Systems

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. D. H. Myszka, Machines and Mechanisms: Applied Kinematic Analysis, Pearson.
2. T. Bevan, The Theory of Machines, CBS Publishers & Distributors.
3. J. J. Uicker, G. R. Pennock and J. E. Shigley, Theory of Machines and Mechanisms, Oxford University Press.
4. R. F. McKay, The Theory of Machines, Hodder & Stoughton Educational.
5. J. A. Collins, Mechanical Design of Machine Elements and Machines, J. Wiley & Sons.
6. R. L. Norton, Design of Machinery, McGraw-Hill Education.
7. W. T. Thomson and M. D. Dahleh, Theory of Vibration with Applications, Pearson.
8. S. S. Rao, Mechanical Vibrations, Pearson.
9. D. J. Inman, Engineering Vibration, Pearson.

ESE-	Nuclear Energy Engineering	3(3-0)

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

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

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**DESCRIBE** the basic nuclear process in fission and fusion reactions	Cognitive	2	1
2.	**ANALYZE** the advanced nuclear reactor systems and the sustainable development of innovative nuclear energy technologies	Cognitive	3	2
3.	**EXPLAIN** the concepts of radioactive waste management for nuclear energy applications	Cognitive	3	3

Course outline:

1. **Introduction:**
   a. Role and importance of nuclear energy,
   b. Particle wavelength, Excited states and radiation,
   c. Nuclear stability and radioactive decay,
   d. Nuclear reaction, Binding energy,
   e. Mass deficit Radioactive decay,
2. **Interaction of radiation with matter:**
   a. Neutron interaction, Cross-sections,
   b. Neutron attenuation, Neutron flux,
   c. Neutron cross-section data,
   d. Energy loss in scattering collision,
   e. Fission, γ-ray interaction with matter
3. **Nuclear reactor:**
   a. Fission chain reaction,
   b. Nuclear reactor fuel,
   c. Nuclear power plants
4. **Nuclear Reactor Systems and components:**
   a. Steam generator,
   b. Pressurizer,
   c. Steam supply system,
   d. Reactor Containment,
   e. Turbine,
   f. Cooling Tower;
5. **Nuclear Detectors:**
   a. Neutron flux, Fick's law,
   b. Equation of continuity,
   c. Diffusion equation,
   d. heat Removal from reactor,

e. Heat generation in reactors,
f. Conduction, Convention,
g. Two Phase Flow,
h. Boiling Heat transfer,

6. Nuclear reactor safety :

a. Reliability, Risk, Safety

Practical:

Experiments related to Nuclear Energy Engineering will be covered in the lab classes

.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Suggested Readings

1. J. R. Lamarsh and A. J. Baratta 2001. Introduction to Nuclear Engineering, 3rd Ed., Prentice Hall.
2. E. E. Lewis. 2009. Fundamentals of Nuclear Reactor Physics
3. R. L. Murray 2009. Nuclear Energy: An introduction to the concepts, systems, and applications of nuclear processes, 6thEdition, Elsevier Inc.
4. R. A. Knief 2008 . Nuclear Engineering Theory and Technology of Commercial Nuclear Power 2008

ESE-	Environmental Impact Assessment	3(3-0)

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

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

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**ACQUIRE** the basic knowledge of environmental impact of engineering projects	Cognitive	2	1
2.	**INVESTIGATE** the environmental problems associated with engineering projects	Cognitive	4	2
3.	**DEMONSTRATE** individually the process of environmental impact assessment	Psychomotor	3	4

Course outline:

1. Introduction to EIA
   a. Definition of environmental impact assessment
   b. EIA as a tool for sustainable development, process and framework for EIA,Guidelines and legal aspects, environmental settings
   c. Components for Environmental Assessment; Screening, Scoping, BaselineStudy, Mitigation, Monitoring, Prediction and Auditing

2. **Methodologies of EIA**
   a. Assessing Regional and Sectoral Level Impacts,
   b. Computational Modeling, GIS Applications,
   c. Knowledge Based Expert Systems and Soft Computing Applications,

3. **Environmental Management Plan**
   a. Challenges in Preparation of EIA Reports,
   b. Case Studies of environmental impact of Engineering Projects,

4. **Future of EIA in Pakistan**:
   a. Status, Problems and Remedial Actions

Teaching Methodology
- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Recommended Text books:

1. Charles H. Eccleston, Environmental Impact Assessment: A Guide to Best Professional Practices, CRC Press
2. Bram F Noble, Introduction to Environmental Impact Assessment: A Guide to Principles and Practice, Oxford
3. Betty Bowers Marriott, Environmental Impact Assessment: A Practical Guide, Mcgraw-Hill

IS-202 Islamic Studies 3(3-0)

APPENDIX

گورنر سیکرٹریٹ کی طرف سے ملنے والا
اور ٹیکنیکل بورڈ آف سٹڈیز سے منظور شدہ نصاب
27/3/07

ہائر ایجوکیشن کمیشن، حکومت پاکستان، اسلام آباد
کی سفارشات کی روشنی میں مرتّب کردہ

نصاب

Islamic Studies (Compulsory)

for B.A./B.Sc.

مطالعہ اسلامیات (لازمی)

بی اے/بی ایس سی

نصاب برائے مطالعہ اسلامیات (لازمی)
بی اے/بی ایس سی

(i) مطالعہ اسلامیات (لازمی) کے لئے 60 نمبر مختص ہونگے۔

(ii) مطالعہ اسلامیات (لازمی) کا کورس سمسٹرز پروگرام میں کم از کم 3 کریڈٹ آورز کا حامل ہوگا۔

(iii) اس مضمون کے نمبر مجموعی نتائج میں شامل کئے جائیں گے اور اسلامیات لازمی ایک کریڈٹ کورس شمار ہوگا۔ اسی طرح اس کورس کے نمبر Agreegate میں بھی شامل کئے جائیں گے۔

I-	معروضی سوالات	10 نمبر
	(معروضی سوالات پورے نصاب پر مشتمل ہوں گے۔)	
(i)	قرآن مجید	20 نمبر
(ii)	حدیث شریف	10 نمبر
(iii)	سیرت النبی ﷺ	10 نمبر
(iv)	اسلامی تہذیب وتمدن	10 نمبر

قرآن مجید:

مطالعہ قرآن مجید کی ضرورت واہمیت

قرآن کریم سے متعلق موضوعات کے بارے میں آیت دی جائے گی اور آیت کی تشریح طلب کی جائے گی۔

(الف) ایمانیات (دلائل کا عقلی ونقلی مطالعہ)

توحید، رسالت، ملائکہ، کتب آخرت کے اثبات پر دلائل۔ ختم نبوت۔ نامور رسالت

(ب) عبادات

نماز، زکوۃ، حج، جہاد

(ج) تفکر وتدبر۔ اسلام کا تصور علم اور تصور اجتہاد

(د) خدمت خلق

(ہ) مومن کی صفات

(و) دعوت دین کی ضرورت واہمیت، نوعیت، امر بالمعروف، نہی عن المنکر

(ز) کسب حلال

قرآن مجید کی مندرجہ ذیل آیت کا ترجمہ وتشریح:

(i) البقرۃ/۲: (آیات نمبر 284 تا 286)﴿للّٰہ ما فی السموت ما فی الارض ..... علی القوم الکفرین﴾ (ایمانیات)

(ii) الحجرات/ 106: (آیات 1 تا 18) موضوع ادبِ نبوی، معاشرتی احکام)

(iii) المومنون/ 23: (آیات 1 تا 11) صفاتِ مومنین)

(iv) الفرقان/ 25: (آیات 63 تا 77) موضوع آدابِ معاشرت)

(v) الانعام/ 6: (آیات 152 تا 154) احکام

(vi) الاحزاب/ 33: (آیات 6-21-40-56-57-58) تخصصات نبوی

(vii) الحشر/ 101: (آیات 18-19-20) فکرِ آخرت۔ عظمت قرآن

(viii) الصّف/ 109: (1 - 14) تفکر وتدبر سے متعلق آیات۔ بشارت بعثت ختم المرسلین۔ دعوت اور اقامت دین

(ix) حم السجدہ/ 42: (آیت نمبر: 53) ﴿سنریھم ایتنا فی الافاق وفی انفسھم حتی یتبین لھم انہ الحق﴾

آل عمران/ 3: (آیات نمبر:190-191)

﴿ان فی خلق السموت والارض واختلاف الیل والنھار لایت لاولی الالباب الذین یذکرون اللّٰہ.....﴾

النحل/ 16: (آیات 12 - 14) ﴿وسخرلکم الیل والنھار﴾

لقمٰن/31: (آیت نمبر20) ﴿الم تروا ان اللّٰہ سخرلکم ما فی السموت وما فی الارض واسبغ علیکم نعمہ.....﴾

حدیث نبوی ﷺ:

مندرجہ ذیل احادیث کا ترجمہ وتشریح:

١۔ عن عبد اللّٰہ قال: قال رسول اللّٰہ ﷺ طلب کسب الحلال فریضة بعد الفریضة (بیھقی شعب الإیمان)

٢۔ عن أبی سعید قال: قال رسول اللّٰہ ﷺ التاجر الصدوق الأمین مع النبیین والصدیقین والشھداء۔

(جامع ترمذی۔ سنن دارمی۔ سنن دار القطنی)

٣۔ عن إبن مسعود عن النبی ﷺ لا تزول قدما إبن آدم حتی یسئل عن خمس عن عمرہ فیما أفناہ وعن شبابہ فیما أبلاہ وعن مالہ مِن أین إکتسبہ وفیما أنفقہ وماذا عمل فیما علم۔ (جامع ترمذی)

٤۔ عن أبی ھریرۃ رضی اللّٰہ تعالیٰ عنہ ، قال: کان رسول اللّٰہ ﷺ یقول اَللّٰھم إنی أعوذبک من الأربع: مِن علم لا ینفع، ومِن قلب لا یخشع، ومِن نفس لا تشبع، ومِن دعاء لا یسمع (رواہ أحمد، وأبو داود، وإبن ماجہ) مشکاۃ المصابیح ج ۲: ص ٦٣، حدیث نمبر ٦٨٦٨)

٥. عن علیؓ قال: قال رسول اللّٰه ﷺ مَن ملك زادا و راحلة تبلغه إلى بيت اللّٰه ولم يحج فلا عليه أن يموت يهودياً أو نصرانياً وذلك إن اللّٰه تبارك وتعالى يقول وللّٰه على الناس حجّ البيت مَن استطاع إليه سبيلاً. (جامع ترمذى)

٦. عن إبن عباسؓ أن النبى ﷺ قال أربع من أعطيهن فقد أعطى خير الدنيا والآخره قلباً شاكراً ولساناً ذاكراً و بدناً على البلاء صابراً و زوجةً لا تبغى حوبا فى نفسها وماله. (سنن نسائى)

٧. عن أبى هريرة رضى اللّٰه عنه أن رسول اللّٰه ﷺ قال: أ تدرون مَا المفلس؟ قالوا : المفلس فينا مَن لادرهم له ولا متاع، فقال: إن المفلس مِن أمتى مَن يأتى يوم القيامة بصلاة وصيام وزكوة، ويأتى قد شتم هذا، وقذف هذا، وأكل مال هذا، سفك دم هذا، وضرب هذا، فيعطى هذا من حسناته، وهذا من حسناته، فان فنيت حسناته، قبل ان يقضى ما عليه اخذ من خطاياهم فطرحت عليه ثم طرح فى النار.

٨. عن أبى هريرةؓ قال : قال رسول اللّٰهﷺ مَن أتاه اللّٰه مالاً فلم يؤدّ زكوة مثل ماله يوم القيامة شجعاً أقرع له زبيبتان يطوقه يوم القيامة ثم يأخذ بلهزمتيه (يعنى شدقيه) ثم يقول أنا مالك وأنا كنزك ثم تلا ولا يحسبن الذين يبخلون بما اتهم اللّٰه من فضله هو خيراً لهم بل هو شراً لهم سيطوقون مابخلوا به يوم القيامة.....(صحيح بخارى)

٩. عن شبرمة بن معبدؓ قال: قال رسول اللّٰهﷺ مروا الصبيان الصلوٰة إذا بلغ سبع سنين وإذا بلغ عشر سنين فاضربوه عليها. أخرجه أبو داود الترمذى ولفظه علّمُوا الصبى الصلوة، إبن سبع سنين واضربوه عليها إبن عشر (صحيح بخارى)

١٠. قال رسول اللّٰهﷺ تجدون شر الناس يوم القيامة ذا الوجهين الذى يأتى هؤلاء بوجه وهؤلاء بوجه. (متفق عليه. أبو هريرةؓ)

١١. قال رسول اللّٰه ﷺ يجاء بالرّجل يوم القيامة فيلقى فى النار فتندلق اقتابه فى النار فيطحن فيها كطحن الحمار برحاه فيجتمع أهل النار عليه فيقولون، أىّ فلانٍ ماشانك؟ أ ليس كنت تامرنا بالمعروف وتنهانا عن المنكر؟ قال: كنتُ أمركم ولا آتيه وأنها كم عن المنكر وآتيه

١٢. عن أبى هريرة قال : قال رسول اللّٰهﷺ مَن سلك طريقاً يلتمس فيه علماً سهل اللّٰه له به طريقاً إلى الجنة، وما إجتمع قوم فى بيت مِن بيوت اللّٰه يتلون كتاب اللّٰه و يتدارسون بينهم إلا نزلت عليهم السكينة وغشيتهم الرحمة وحفتهم الملٰئكة وذكرهم اللّٰه فيمَن عنده، ومن بطابه عمله لم يسرع به نسبه (مسلم)

١٣۔ قال رسول اللّٰہ ﷺ إن أثقل شئ یوضع فی میزان المؤمن یوم القیامة خلق حسن، وإن اللّٰہ یبغض الفاحش البذی. (ترمذی ابو الدرداء)

١٤۔ عن عمر بن الخطاب قال: قال رسول اللّٰہ ﷺ حین سُئِل عن الإیمان أن تؤمن باللّٰہ وملائکته وکتبه ورسوله والیوم الآخر وتؤمن بالقدر خیره وشره. (متفق علیه)

١٥۔ عن العباس بن عبد المطلب قال: قال رسول اللّٰہ ﷺ ذاق طعم الإیمان مَن رضی باللّٰہ رباً وبالاسلام ديناً و بمحمد رسولاً.

١٦۔ عن أنس قال قال رسول اللّٰہ ﷺ والذی نفسی بیده لا یؤمن عبد حتی یحب لأخیه مایحب لنفسه. (متفق علیه)

١٧۔ عن النعمان بن بشیر قال: قال رسول اللّٰہ ﷺ تری المؤمنین فی تراحمهم وتوادهم وتعاطفهم کمثل الجسد إذا اشتکی عضو تداعی له سائر الجسد بالسهروالحمی. (متفق علیه)

١٨۔ عن إبن عمر رضی اللّٰہ عنها قال: قال رسول اللّٰہ ﷺ بُنی الإسلام علی خمس شهادة أن لا إله إلا اللّٰہ وأن محمداً عبده ورسوله. وإقام الصلوٰة وإیتاء الزکوٰة والحج وصوم رمضان. (متفق علیه)

١٩۔ عن أبی سعید الخُدری عن رسول اللّٰہ ﷺ قال مَن رأی منکم منکراً فلیُغیّره بیده فان لم یستطع فبلسانه إن لم یستطع فبقلبه وذلك أضعفُ الإیمان. (رواه مسلم)

٢٠۔ عن عبد اللّٰہ بن عمر قال: قال رسول اللّٰہ ﷺ ألا کلکم راعٍ وکلکم مسئولٌ عن رعیته فالإمام الذی علی الناس راع وهو مسئول عن رعیته والرّجل راع علی أهل بیته وهو مسئول عن رعیته والمرأة راعیة علی بیت زوجها وولده وهی مسئولة عنهم وعبد الرّجل راع علی مال سیده وهو مسئول عنه ألا فکلکم راع وکلکم مسئول عن رعیته. (متفق علیه)

سیرت النبی ﷺ:

(i) مطالعہ سیرت النبی ﷺ کی ضرورت واہمیت

(ii) تزکیہ نفس اور تعمیر سیرت وشخصیت کا نبوی منہاج

(iii) اقامت دین کا نبوی طریق۔ خلافت

(iv) اجتماعیت وتشکیل معاشرت اور اسوہ حسنہ۔ اخوت واتحاد وامت

(v) قرآن مجید میں سیرت سرور دو عالم ﷺ کا بیان

(vi) غزوات نبوی۔ مقاصد وحکمت

تہذیب وتمدن:

تہذیب کا مفہوم، اسلامی تہذیب کی خصوصیات

حسن معاشرت

فضائل اخلاق۔ رذائل اخلاق

حقوق العباد۔ حقوق نسواں۔ تربیت اولاد۔ حلال وحرام۔ غیر مسلموں سے تعلقات۔ عدل۔ احسان۔ ایتائے ذی القربیٰ۔

بنیادی انسانی حقوق۔ حجۃ الوداع۔ ماحولیات۔ قرآن حکیم کا یہود، نصاریٰ، مشرکین اور منافقین سے مکالمہ۔

تہذیب انسانی کے ارتقاء میں مسلمانوں کا کردار

درج ذیل علوم ومیادین زندگی میں مسلمانوں کی خدمات کا اجمالی جائزہ:

طبعی علوم۔ حیاتیاتی علوم۔ معاشرتی علوم۔ انتظامیات (ایڈمنسٹریٹو سائنسز) ماحولیات۔ زراعت

مجوزہ کتب:

۱۔	اسلامی نظریہ حیات	خورشید احمد
۲۔	اسلام کا معاشرتی نظام	خالد علوی
۳۔	رحمۃ للعالمین	سلیمان منصور پوری
۴۔	الرحیق المختوم	صفی الدین مبارکپوری
5-	Introduction to Islam	Hameed ullah

MATH-301 Linear Algebra & Calculus 3(3-0)

Objective

To learn fundamentals of algebra & calculus.

Contents

Basic set theory: Complex numbers: Cartesian and polar form, De Moivre's theorem, roots, exponential, trigonometric, hyperbolic and logarithmic functions', complex powers.

Matrices: square matrices, determinants, reduced echelon form, rank, eigen-values, eigen-vectors, Markov processes, mass transient problem, forecasting of weather and develop the solution of system of differential equations for mechanical systems/electrical systems/agricultural/civil engineering especially in public health engineering problem, linear transformation, modeling and solution of system of linear equations.

Vector spaces: group, subgroup, ring, field, vector space, subspace, linear independent and linearly dependent set of vectors, spanning set, basis for a vector space and its applications in engineering.

Differential calculus: limit, continuity, derivative, total differential, higher order

differentiation, tangent and normal, Taylor series, Maclaurin series, extreme values, 1st and 2nd derivative test, point of inflection and its applications in business and engineering.

Integral calculus: limit of sum, Riemann integration, evaluating integrals, definite integrals, area under a curve and other applications of integration.

Suggested Readings:

1. Kreyszig, E. 2000. Advanced Engineering Mathematics, Ed. 8th, John Wiley and Sons, New York.
2. Yusuf, S.M. and M. Amin. 2002. Mathematical Methods, Ilmi Kitab Khana, Kabir Street Urdu Bazar, Lahore
3. Thomas, G.B. and R. L. Finney. Calculus and Analytical Geometry, 2002, Ed.9th Roohani Press, Islamabad.

PY-301 Applied Physics 3(2-1)

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

Course outcome:

COURSE LEARNING OUTCOMES:

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	Illustrate the electromagnetic phenomena and fields mathematically.	Cognitive	C2	1
2.	Interpret basic electric circuits used in science and engineering.	Cognitive	C3	1
3.	Examine the mechanical phenomena including straight line motion and simple harmonic motion along with their mathematical models.	Cognitive	C2	1

Course outline:

1. Electric Charge

a. Introduction to electric charge
b. Conductors and Insulators
c. Coulomb's Law
d. Charge is quantized
e. Charge is conserved

2. Electric Fields

a. Introduction to Electric Field
b. Electric field lines
c. The electric field due to point charge
d. The electric field due to electric dipole
e. The electric field due to line of charge
f. The electric field due to a charged disk
g. A point charge in electric field
h. A dipole in electric field

3. Gauss' Law

a. Introduction to Gauss' law
b. Flux
c. Flux of an electric field
d. Gauss' Law and its applications
e. Gauss' law and Coulombs' Law
f. Applying Gauss' law to Cylindrical Symmetry
g. Applying Gauss' law to Planner Symmetry

h. Applying Gauss' law to Spherical Symmetry

4. Electric Potential

a. Introduction to electric potential
b. Electric potential energy
c. Electric potential
d. Calculating the potential from the field
e. Potential due to a point charge
f. Potential due to group of charges
g. Potential due to an electric dipole
h. Potential due to continuous charge distribution

5. Capacitance

a. Introduction to capacitance
b. Calculating the capacitance
c. Capacitors in parallel and series
d. Energy stored in an electric field
e. Capacitors with dielectric
f. Dielectric and Gauss' Law

6. Current and Resistance

a. Introduction to electric current
b. Current density
c. Resistance and Resistivity
d. Ohm's Law
e. Power in electric circuits
f. Semiconductors and super conductors

7. Circuits

a. Introduction to electric circuits
b. Pumping charges
c. Work, energy and EMF
d. Calculating the current in single loop circuit
e. Multi loop circuits
f. The RC Circuits
g. The ammeter and voltmeter

8. Magnetic Fields

a. Introduction to magnetic fields
b. What produce magnetic field
c. The Hall effect
d. A circulating charge particle
e. Magnetic force on a current carrying wire
f. Torque on a current loop

9. Motion in 1-D, 2-D and 3-D

a. Position, velocity and acceleration
b. Projectile motion
c. Simple Harmonic Motion

10. Newton's Law and its applications

a. Newton's Law
b. Applying Newton's law
c. Friction
d. Drag Force and terminal velocity

Practical:
Experiments related to Applied Physics will be covered in the lab classes.
Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment
Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Recommended Books:

1. University Physics by Hugh D. Young and Roger A. Freedman, 14th Edition.
2. Fundamentals of Physics Extended by D. Halliday, R. Resnick, J. Walker. 10th edition.
3. Fundamentals of Electromagnetic Phenomenon by D. Corson & Lorrain.
4. Theraja, B.L. 2004. A Text Book of Electrical Technology. S. Chand & Co. Ltd. New Delhi, India.

CS-401 Computer Programming Fundamentals for Engineers 3(2-1)

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

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

S.No	CLO	Domain	Taxonomy level	PLO
1.	**UNDERSTAND** the basic knowledge of computer, concepts of programming	Cognitive	2	1

	techniques and use them efficiently.			
2.	**APPLY** the programing skills to solve engineering problems.	Cognitive	3	2
3.	**DEMONSTRATE** individually to develop maintainable and reusable solutions using approaches introduced in the course.	Cognitive	3	3

Course outline:

1. Introduction
- a. Introduction to computers
- b. Interacting with Computer
- c. Hardware: Computer components
- d. Software: Operating system

2. Software development process
- a. Algorithm
- b. Pseudocode
- c. Flowchart
- d. The software development cycle

3. Programming basics
- a. Constants and variable
- b. Data types
- c. C++ operators
- d. Standard input output operations

4. Control Structures and Functions
- a. Conditional statements
- b. Selection statements
- c. Programmer defined functions
- d. Parameter passing.

5. Arrays
- a. Array implementation
- b. Arrays and functions

6. Pointers
- a. Address and pointer variables
- b. Dynamic Memory Allocation
- c. Pointers and Arrays
- d. Functions and Pointers
- e. Functions and address variables
- f. Functions, pointers and arrays

7. Characters and Strings
- a. Fundamentals of strings

b. String manipulation and libraries

8. File Handling

a. Reading and writing to permanent storage

Practical:

Experiments related to Computer Programming Fundamentals for Engineers will be covered in the lab classes.

Teaching Methodology

- Lecturing
- Written Assignments/Quiz
- Guest Speaker
- Field Visits
- Report Writing

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Text and Reference books:

1. Perry, G. and M. Johnsons. 1992. Turbo C++ by Examples. Prentice Hall Computer Publishing. New York, USA..
2. Shelly and Cashman. 1995. Using Computer, a Gateway to Information. 2nd Ed. Boyd and Fraser Publishing Company, USA.
3. Robert Lafore, "Object-Oriented Programming in C++", Prentice Hall, ISBN: 0672323087, (Latest Edition).

MATH-401 Differential Equations, Power Series, Laplace Transform 3(3-0)

Contents

Ordinary Differential Equation: Basic concepts of ordinary differential equation, General and particular solution, Initial and boundary condition, Linear and nonlinear differential equations, Solution of first order differential equation by separable variables and its application in our daily life situations, Techniques like change in variables homogeneous, non-homogeneous, exact, non-exact, linear and non-linear Bernoulli could be used in case of complications. Solution of second order differential equations by theory of operators and its application as forced and free oscillations, the extension of second order solution criteria to high order differential equations, solution of the system of differential equations by theory of operators and its application in daily life situations. Partial Differential Equations: Basic Concepts, linear and non-linear P.D equations, Quasi linear and Quasi non-linear P.D equations, homogenous and non-homogenous P.D equations, solutions of P.D equations, boundary and initial conditions as dirichlet conditions, Neumann' s

condition, Robbin's/mixed condition, classification of P.D equations as Elliptic conditions, Parabolic and hyperbolic. Analytic Solution by separation of Variables of the Steady State, two dimensional heat equation/Laplace equation and un-steady one dimensional heat equation/Diffusion equation with homogenous and non-homogenous boundary conditions. D'Alembert's solution of two dimensional wave equation homogenous and non-homogenous boundary conditions. Fourier Series: Periodic waveforms and their Fourier representations, calculating a Fourier series, Fourier series of odd and even functions, Half range Fourier series, Fourier series solution for the above P.D equations.

Suggested Readings

1. Kreyszig, E. 1999. Advanced Engineering Mathematics. John Wiley and Sons, New York, USA.
2. Yousaf, S.M. 1998. Mathematical Methods, Ilmi Kitab Khana Kabir Street, Urdu Bazar, Lahore, Pakistan.
3. Sharma, G.S., K.L. Auhuja and I.J.S. Sarna.1988. Advanced Mathematics for Engineers and Scientists. Tata McGraw Hill Co., India.

SSH-102 Pakistan Studies 2(2-0)

Contents

Historical Perspective: Two nation Theory; Ideology of Pakistan; Objectives for the creation of Pakistan; Important personalities in the creation of Pakistan; Sir Syed Ahmad Khan; Allama Iqbal; Quaid-e-Azam. Constitutional Development in Pakistan: Objectives Resolution and its constitutional importance; Ulma's 22 points; Islamic provisions of 1956 constitution; Islamic provisions of 1962; Constitution; Islamic provisions of 1973 constitution. Contemporary Pakistan: Objectives of Pakistan's foreign policy; An overview of Pakistan's foreign Policy; Pakistan's foreign policy towards her neighboring countries; Regional organizations.

Suggested Readings

1. Amin, Shahid. 2010, Pakistan's Foreign Policy, Oxford University Press, Karachi.
2. G. Allana. 2010, Our Freedom Fighters, Ferozesons Pvt. Ltd., Lahore
3. Hussain, Anjum, Zahid. 2010, Encyclopedia of Pakistan, Jahangir Book Depot, Lahore, Pakistan.
4. Khan, H. 2010. Constitutional and Political History of Pakistan. Oxford University Press, Karachi, Pakistan.
5. Mehmood, Safdar. 2010, International Affairs, Jhangir Book Depot, Lahore,Pakistan.

ENG-101 English Composition and Comprehension 3(3-0)

Contents

Composition: Adverb and Adjectives; their forms and use; Articles and their use, prepositions ; Relative pronouns, clauses; Conditional sentences; Correction of sentences.

Comprehension: Getting the essential information; Effective communication; Comprehension writing, rules, practice;

Order of importance: Application for job; Technical Report writing; Essay writing;

Critical Reading and Thinking: The Damned Human Race (Article); How to live to be 200 (Article)

Suggested Readings

1. Advance Publishers, 2010, Advance Essays for All, Advance Publishers, Muslim Centre, Urdu Bazar, Lahore.
2. Ahmad, A. 2009, To The Point (English Grammar & composition for degree), To the point publishers, 5-A. Yousaf Market, Ghazni Street, Urdu Bazar, Lahore.
3. Atta –Ur-Rehman, S., 2010. Effective Business Communication and Report Writing, Farrukh & Brothers, P.O Box 9025, Lahore.
4. Khan, N. and G.S. Qureshi 2011. A Selection of English Prose, The Carvan Book House, Katchery Road, Lahore.
5. Khan, Z. R., 2009, Simple Grammar and Composition (B.Sc English), Simple Publishers, 14 - Iqra Centre, Urdu Bazar, Lahore.

RS-401 Sociology for Engineers 2(2-0)

Contents:

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, Groupthink, Conformity. Types of Disputes: Dispute Resolution Techniques; Participatory Irrigation Management; Organizational Techniques for Sustainable Social Organizations: A Case Study; Community Development: A Case Study of AKRSP.

Suggested Readings:

1. Bhatti, M.A., M.A. Cheema and G.V. Skogerboe. 1999. Maintenance and Operational Activities in the Command Area of Shahpur and Mirwal Small Dam. Pakistan National Program International Irrigation Management Institute Lahore. Report No. R-78.
2. James, W. and V. Zanden. 1988. The Social Experience: An Introduction to Sociology. Random House, 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.
4. Charles D Fledderman, Engineering Ethics, Prentice Hall, New Mexico, 1999.

AEE-302 Communication & Presentation Skills 3(2-1)

Contents:
Definition, types and functions of communication; effective communication and its barriers; verbal communication skills; speaking, speech making, listening, reading and writing. Preparing and delivering a speech, development of effective reading skills, art of effective writing, writing scientific and popular articles. Listening: the process, types, barriers and strategies for effective listening; non-verbal communications; characteristics, functions and types; leadership; concept, techniques, functions and characteristics; development of effective leadership skills.

Practical:
Communication & Presentation Skills labs related to speaking, speech making, listening, reading and writing.

Suggested Readings:
1. Calvert, P. (Ed.). 1990. The communication's Hand Book: Techniques and Technology. Maupin House, USA.
2. Devito, J.A. 1997. Human Communication: The Basic Course. Addison Wesley Longman, Inc., New York, USA.
3. Gronbeck, B.E., R.E. McKerrow, D. Ehninger and A.H.Monroe. 1974. Principles and Types of Speech Communication. Harper Collins College Publishers, New York.
4. Kossen, S. 1994. The Human Side of Organizations.Harper Collins College Publishers, New York, USA.
5. Roy, E. and S. Roy. 1993. Guide to Basic Writing. Prentice Hall. Englewood Cliffs. New York, USA.

STAT-402 Statistics and Probability 3(2-1)

Contents:
Statistics: Mean value, Measures of central tendency, Measures of variation, Standard deviation, Expected value of a random variable, Standard deviation of a random variable, The Poisson distribution, The uniform distribution, The exponential distribution, The normal distribution, The standard normal, The standard normal distribution. Probability**:** Sets,

Application of Venn Diagrams, Introducing probability, Mutually exclusive events, The addition law of probability, Complementary events, Concepts from communication theory, Problems related to engineering, Conditional probability, The multiplication law, Independent events, Baye's formula, Permutations and combinations, Multiplication principle, Problems related to engineering, science and management, Applications of counting, Bernoulli trials, Binomial probability, Markov chains, Probability distribution, Expected value, Decision making, Problems related to engineering and management.

Practical:

1. Simple, Multiple and Component bar diagram.
2. Historigram, Frequency polygon,
3. Frequency curve, c.f. curve, cumulative percentage curve and locate Quantiles.
4. Problem assignments relating probability.
5. Fitting a Binomial distribution.
6. Fitting a Poison distribution.
7. Fitting a Normal distribution.
8. Sampling distribution of difference between two means.
9. Application/use of t-test for Null hypothesis.
10. Test of significance of association of attributes by x^2-test (chi-square test).
11. Testing goodness of fit.
12. Calculating a simple, partial and a multiple correlation and their tests of significance. Fitting a simple linear regression equation and its test of significance by Analysis of Variance (F-test) and t-test.
13. Analysis of variance of data from C.R.D., R.C.B.D. and L.S. design.

Suggested Readings:

1. Choudhry, S.M. and S. Kamal. 1998. Introduction to Statistical Theory Part I & II; Ilmi Kitab Khana, Kabir Street, Urdu Bazar, Lahore, Pakistan.
2. Erwin Kreyszig, Advanced Engineering Mathematics 8th Edition, John Wiley & Sons Publication.
3. Lind, D., W. Marchal, and S. Wathen. 2011. Basic Statistics for Business and Economics with Formula Card (7th ed.). The Mcgraw-Hill/Irwin Series Operations and Decision Sciences, McGraw Hill Co., India.
4. Miller I. and J.E. Freund. 1985. Probability and Statistics for Engineers. Prentice Hall, Inc., Englewood Cliffs, New Jersey, USA.
5. Muhammad, F. 1999. Statistical Methods and data analysis; Kitab Markaz, Bhowana Bazar, Faisalabad, Pakistan.
6. Ronald E. Walpole. 1982. Introduction to Statistics; McMillan publishing Co., Inc. New York. USA.

7. Taylor, L.D. 1974. Probability and Mathematical Statistics. Harper & Row, Publishers New York, USA.
8. Walpole R.E. 1982. Introduction to Statistics, McMillan publishing Co, Inc. New York.

BBA-602 Operations Management 2(2-0)

Objective:
This course is designed to provide the student with an understanding of the foundations of the operations function in both manufacturing and services. The Course will analyze operations from both the strategic and operational perspectives and highlight the competitive advantages that operations can provide for the organization. The goal of the course is to help students become effective managers in today's competitive, global environment. The course will examine operations as a competitive weapon, demand forecasting, supply-chain management, aggregate planning, inventory systems, just in-time systems and material requirements planning.

Contents
Introduction to operations management, competitiveness, strategy and productivity, Operations management models, Forecasting, Decision making, Transportation models, Waiting lines models, Learning curves, System Design, Product and service design, Strategic capacity planning for products and services: Decision theory process, Selection and facility layout: Linear programming, Design of work systems: Learning curves, location planning and Analysis: The management, Quality Control, Sampling Inventory Management and Scheduling, Inventory Management, Aggregate Planning, MRP, ERP, JIT and Learn Operations: Maintenance, Scheduling, Supply Chain Management, Supply Chain Strategies, Vendor selection, Internet purchasing, Supplier quality, Benchmarking, Types of facilities and location analysis techniques. Transportation and distribution system, Project management, Waiting lines and simulations, Layout strategy, Basics layouts, Designing process layouts, Designing product layouts, Warehousing and storage layouts, Assembly line balancing, Hybrid Layouts.

Suggested Readings:
1. William, J. S. 2012. Operations Management, International Edition, 8th Edition, Publisher, McGraw Hill, UK.
2. Heizer, J. and Barry B. Render, 2012. Operations Management, 11th Edition. Prentice Hall, UA.
3. Roberta, S.R. and Taylor, W.B. 2012. Operations Management: Creating Value Along the Supply Chain, 4th edition. McGraw Hill, UK.

MICRO-501 Microbial Bioenergy and Biofuel 3(2-1)

Learning Objectives:

After completing the course the students will be able to:

i. Familiarize with different types of microbes associated with bioenergy.
ii. Understand role of microbes in producing Bioenergy and Biofuel.
iii. Lab. scale production of bioenergy and biofuel using conventional digester.

Contents:

Types of biomass (e.g. wood waste, forestry residues, agricultural residues, organic municipal solid waste). Types of microbial fuels (Biodiesel, Bioethanol, Biomethane/Biogas, Biohydrogen etc,), Phenomena for production of Biofuel (bioenergy and biofuel etc.), role of microbes (aerobic and anaerobic) in biofuel production and isolation and characterization of different aerobic and anaerobic. Isolation and characterization of biofuel producing bacteria (Biodiesel; *E. coli*, Microalgae, Biomethane; Methanogenic archae (Biohydrogen, Cyanobacteria, Clostridia, Bioalgae, Botryococcus bruanici, PNS Bacteria. Bioethanol (*Lactobacillus casei*, *saccharomyces cerevisiae*, *Zymomonas morbilis*, *klebsiella oxytoca, E.coli, Clostridium cellulyticum,* Preparation and studies of Consortium of microbes useful in Bioenergy/Biofuel. Microbial fuel cell.

Practical:

Standard operating Lab procedures (safety measures and microbiology lab), sterilization protocol for lab equipment and glassware's. Equipment's used in isolation and characterization of biofuel producing bacteria, Different aerobic and anaerobic. Techniques helpful in isolating anaerobic biofuel forming Bacteria, Growth media, characterization with the help of morphology, biochemical tests, fluorescence test and other serological and molecular test, demonstration of laboratory scale conventional digester used in biofuel production. Visit to biofuel plant.

Recommended Books:

1. Ruban Packiasamy, 2013. Seasonal Distribution of Methanogens in Manimuthar River
2. Padam Prakash Bhojvaid, 2006. Biofuels: Towards a Greener and Secure Energy Future
3. Rajesh Arora, 2012. Microbial Biotechnology: Energy and Environment
4. Samir Khanal, 2008. Anaerobic Biotechnology for Bioenergy Production: Principles and Applications

5. Patrick C. Hallenbeck, 2012. Microbial Technologies in Advanced Biofuels Production

CHEM-405 Photoactive Materials and Their Characterization 2(2-0)

Learning Objectives:
To train students about the use of different materials for the fabrication of photoactive materials in Nano scale which possess maximum ability to harvest the sun light in visible region. Furthermore the working and principles as well as the characterization of solar cells. In the practical domain the use of potentiostat and cyclic voltametry is prime importance.

Contents
Introduction to Solid State Physics and Chemistry, Fabrication of nanostructure materials using semiconductor oxides, sulphides etc. Principles for measuring the band gap of semiconductors materials. Strategies to manufacture different morphologies of photoactive materials. Characterization of photoactive materials using spectroscopy, microscopy (SEM, TEM) and X-ray diffraction. Measurement of current voltage characteristics of the solar cells. Basics of Crystallography. Basic principles of electrochemistry, Role of electrolytes in the formation of the photovoltaic cells. Types of electrolytes and their limitations. Photo electrochemical cell. Electrodes and their selection. Dark current and light current. Concept of recombination of charges. Forward and reverse biasing.

Practical:
Photometric measurement, preparation of their films of photoactive materials, measurement of conductance, surface area demonstration, light intensity measurement.

Suggested Readings:

1. Wong, J. 2006. Analytical electrochemistry (3rd ed.). Publishers John Willey & Sons, USA.
2. Christopher M.A.B. and A. Maria Brett. 1992. Electrochemistry Principles, Methods, and Application. Publisher Oxford University Press.
3. John McHardy and F. Ludwig. 1992. Electrochemistry of Semiconductor and Electronics Publisher Noyes Publications, USA.
4. Nelson, J. 2003. The Physics of Solar Cells. Imperial College Press, UK.
5. Kurla, S.P. 2013. Essentials of solid state physics. Publisher New Central Book Agency (P) Ltd. London.

FMP-504 Professional Ethics 2(2-0)

Learning Objectives:
The objective of the course is to improve the ethical standards of students in engineering.

Contents
Senses of Engineering Ethics – Variety of moral issues – Types of inquiry – Moral dilemmas. Moral Autonomy – Kohlberg's theory – Gilligan's theory – Consensus and Controversy – Professions and Professionalism – Professional ideals and virtues – Theories about right action – Self-interest – Customs and religion – Use of Ethical Theories.
Engineering as experimentation – Engineers as responsible experimenters – Codes of Ethics – A Balanced Outlook on Law – The Challenger Case Study.
Safety and risk – Assessment of safety and risk – Risk Benefit Analysis – Reducing risk – The Three Mile Island and Chernobyl Case Studies
Collegiality and loyalty – Respect for Authority – Collective Bargaining – Confidentiality – Conflicts of Interest – Occupational Crime – Professional Rights – Employee Rights – Discrimination.
Multinational Corporations – Environmental Ethics – Computer Ethics – Weapons Development – Engineers as Managers – Consulting Engineers – Engineers as Expert Witnesses and Advisors – Moral Leadership – Sample code of conduct.

Suggested Readings:

1. Mike Martin and Roland Schinzinger, Ethics in Engineering, McGraw Hill, New York, 1996
2. Charles D Fledderman, Engineering Ethics, Prentice Hall, New Mexico, 1999
3. Laura Schlesinger, How Could You Do That: The Abdication of Character, Courage, and Conscience, Harper Collins, New York, 1996.
4. Stephen Carter, Integrity, Basic Books, New York 1996.

Energy and Management 2(2-0)

Contents:
Energy and its forms , energy resources, types, uses, merits and demerits of developing and using energy resources in Pakistan, Non-renewable and renewable patterns of energy consumption in Pakistan, future energy scenario of World and Pakistan, sustainable energy management in Agriculture, transport industry and domestic sectors.

Impact of energy systems on environment and human health, impact of modern agriculture transport and industrial development on environment. Carbon Credit Policy

Suggested Readings:

1. Botkin, D.B. and Keller 2007. Environmental Science: Earth as a Living Planet. 6th edition. John Wiley and Sons.
2. Mckilley, M.L., R.M. Schoch and Yonavjak. 2007 Environmental Science: systems and Solutions, 4th Edition. Jones and Bartlett Publishers.

POSTGRADUATE COURSES AND SCHEME OF STUDIES

Sr. No	Course Title	Credit Hours
1.	ENERGY AUDIT AND MANAGEMENT	3(2-1)
2.	SOLAR THERMAL ENGINEERING	3(2-1)
3.	BIO ENERGY ENGINEERING	3(2-1)
4.	HYBRID POWER SOURCES	3(2-1)
5.	HYDRO POWER PLANTS	3(2-1)
6.	WIND ENERGY ENGINEERING	3(2-1)
7.	INSTRUMENTATION IN ENERGY SYSTEMS	3(2-1)
8.	REFRIGERATION AND AIR CONDITIONING	3(2-1)
9.	POWER ELECTRONICS AND MOTOR DRIVES	3(2-1)
10.	ELECTRICAL POWER TRANSMISSION AND DISTRIBUTION	3(2-1)
11.	ENERGY SYSTEMS MODELLING AND SIMULATION	3(2-1)
12.	ADVANCED CLEAN COAL TECHNOLOGIES	3(3-0)
13.	COMBUSTION AND POLLUTION CONTROL	3(2-1)
14.	HYDROGEN TECHNOLOGIES AND FUEL CELLS	3(2-1)
15.	ENERGY MANAGEMENT IN BUILDINGS	3(2-1)
16.	SOLAR PHOTOVOLTAIC SYSTEMS	3(2-1)
17.	BIOFUELS ENGINEERING	3(2-1)
18.	NUCLEAR POWER PLANT ENGINEERING	3(3-0)
19.	COMPUTER APPLICATIONS IN ENERGY SYSTEMS	3(3-0)

20.	DEVELOPMENT AND EVALUATION OF ENERGY PROJECTS	3(3-0)
21.	FLUID FLOW AND HEAT TRANSFER	3(2-1)

SCHEME OF STUDIES FOR
MS/ME ENERGY SYSTEMS ENGINEERING

ESE- ENERGY AUDIT AND MANAGEMENT 3(2-1)

Learning Objectives:

To train the students about energy management, monitoring and auditing.

Contents:

Energy Overview – Energy Management Techniques, Role of Energy Managers in Industries- Energy monitoring, auditing & targeting – Economics of various Energy Conservation schemes. Total Energy Systems Energy Audit -various Energy Conservation Measures in Steam -Losses in Boiler. Energy Conservation in Steam Systems -Case studies. Energy conservation in Centrifugal pumps, Fans & Blowers, Air compressors– energy consumption and energy saving potentials – Design consideration.
Refrigeration & Air conditioning - Heat load estimation -Energy conservation in cooling towers & spray ponds – Case studies Electrical Energy -Energy Efficiency in Lighting – Case studies. Organizational background desired for energy management motivation, detailed process of M&T-Thermostats, Boiler controls- proportional, differential and integral control, optimizers; compensators.

Practical:

The practical work will be based on Theory Work.

Suggested Readings:

1. Eastop T.D & Croft D.R, 1990, Energy Efficiency for Engineers and Technologists, Logman Scientific & Technical, ISBN-0-582-03184.
2. Reay D.A, Industrial Energy Conservation, 1stedition, Pergamon Press, 1977.
3. Larry C Whitetal, Industrial Energy Management & Utilization.
4. D P Kothari, I J Nagrath, 2008, Power System Engineering 2nd Ed., Tata McGraw-Hill Co.

ESE- SOLAR THERMAL ENGINEERING 3(2-1)

Learning Objectives:

To impart the sound knowledge of solar thermal system design in order to utilize the solar energy for the communities.

Contents:

Solar resource assessment, extraterrestrial radiation on horizontal surfaces, available solar radiation and total radiation on slopped surfaces; solar charts, pyrheliometer, pyranometer, pyregeometer, net pyradiometer-sunshine recorder. Heat transfer in solar systems: natural convection between parallel flat-plates, heat transfer relations for internal flow; radiation characteristics of opaque materials; radiation transmission through covers and absorption by collector; transmittance-absorptance product, monthly average absorbed solar radiation; theory of flat-plate collectors: collector overall heat loss coefficient, collector heat removal factor and flow factor, mean fluid and plate temperature, heat capacity effects on flat-plate collectors; flat-plate collector performance: incidence angle modifier, thermal test data conversion; design of solar heating systems, passive solar energy systems. Case studies related to active and passive use of solar energy.
Design of concentrated collectors, and performance analysis, classification - concentrator mounting –Focusing solar concentrators-parabolic trough concentrators, paraboloidal concentrators, Scheffler fixed focus concentrators, Heliostats. Automatic tracking systems, energy storage, distillation still and solar cookers. Solar-based Sterling Engine, solar process economics; cost of solar process systems, life cycle savings methods.

Practical:

The practical work will be based on Theory Work.

Suggested Readings:

1. Duffie, J. A.; Beckman, W. A. (latest edition). Solar engineering of thermal processes.John Wiley and Sons, New York.
2. Kaltschmitt, M., Streicher, W., and W. Andreas (2007). Renewable Energy: Technology, Economics and Environment. Springer Publishers.
3. D. Yogi Goswami, Frank Kreith, Jan. F. Kreider, Principles of Solar Engineering, 2nd Edition, Taylor & Francis, 2000, Indian reprint, 2003
4. Edward E. Anderson, “Fundamentals for solar energy conversion”, Addison Wesley Publ. Co., 1983.

5. Duffie J. A and Beckman, W .A., 2006, Solar Engineering of Thermal Process, John Wiley and Sons.

ESE- BIO ENERGY ENGINEERING 3(2-1)

Learning Objectives:

To acquaint the students with the knowledge of biomass resources, combustion, and their power generation potential.

Contents:

Sources and Classification. Chemical composition, properties of biomass. Energy plantations, Size reduction, Briquetting, Drying, Storage and Supply chain management of biomass, Energy reclamation from agricultural crops/wastes, Different sources of biomass for energy production, Different components and efficiency calculation of biomass fired boilers, Thermo chemical conversion of lignocelluloses biomass. Incineration, Processing for liquid fuel production. Pyrolysis -Effect of particle size, temperature, and products obtained. Thermo chemical Principles: Effect of pressure, temperature, steam and oxygen. Fixed and fluidized bed Gasifiers- Partial gasification of biomass by CFB, types, design, development and evaluation of gasifier for heat and power generation. Combustion of woody biomass-Design of equipment. Cogeneration using bagasse- Case studies: Combustion of rice husk.
Feedstock for biogas, Microbial and biochemical aspects- operating parameters for biogas production, Anaerobic digestion for methane production- basic processes, anaerobic fermentation, fermentation kinetics, digester design parameters, various types of biogas plants. Design, installation, operation and management of biogas plants, purification of biogas. Power generation from biogas plants, Concept of CHP in energy production, gas and digester effluent utilization strategies, design of efficient bio-digesters; Kinetics and mechanism- High rate digesters for industrial waste water treatment.

Practical:

The practical work will be based on Theory Work.

Suggested Readings:

1. Chakraverthy A, 1989, Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes", Oxford & IBH publishing Co.

2. D. Yogi Goswami, Frank Kreith, Jan. F .Kreider, 2000, Principles of Solar Engineering, 2nd Edition, Taylor & Francis.
3. Mital K.M, 1996, Biogas Systems: Principles and Applications. New Age International publishers Pvt. Ltd.
4. Nijaguna, B.T., 2002. Biogas Technology. New Age International publishers Pvt. Ltd.
5. Rezaiyan. J and N. P. Cheremisinoff, 2005, Gasification Technologies, A Primer for Engineers and Scientists. Taylor & Francis Publishers.
6. Khandelwal. K. C. and Mahdi S. S., 1986, Bio-Gas Technology. Tata McGraw-Hill Pub. Co.Ltd.

ESE- HYBRID POWER SYSTEMS 3(2-1)

Learning Objectives:

To impart the sound knowledge regarding innovative technologies related to hybrid power of automobiles.

Contents:

History of Electric Vehicles, Electrochemical Power Sources, Electric Vehicle Debate, Primary Energy Sources and Alternative Fuels for Transportation– Secondary Batteries and Fuel Cells.

Sources- Aqueous Electrolyte Batteries –Lead Acid, Nickel – Iron, Nickel – Zinc, Metal –Air Zinc-Halogen Non Aqueous Electrolyte Batteries- High Temperature Batteries, Organo Electrolyte and Solid State Batteries. Overview of Performances of Candidate Secondary Battery Systems-Fuel Cells – Acid Systems, Direct Methanol / Air Systems, Alkaline Systems-Overview of Performances of candidate Fuel Cell Systems, SOFC-Emerging areas in Fuel cells Fuel cell outlook, Sources, comments, & revision history, Applications –Industrial and commercial, Battery/Fuel cell/ Internal Combustion Engine Hybrid Electric Vehicles, Laboratory Test of Electric Vehicle Batteries, Vehicle tests with Electric Vehicle Batteries, Future of Electric Vehicles, Emerging trends in batteries. Specifications - Storage cell definitions & specifications, Carbon-zinc & alkaline cells, Battery -Storage Cell Technologies-Storage cell fundamentals-Characteristics, solar based electric vehicles, design principles of electronic control of hybrid vehicles.

Practical:
The practical work will be based on Theory Work.

Suggested Readings:

1. B.D. McNicol and D.A.J. Rand, 1998, Power Sources for Electric Vehicles. Elsevier Publications.

2. John Voelcker, 1990, Lithium Batteries for Hybrid Cars. Spectrum Publishers.
3. David Linden and Thomas, 2002, Hand Book of Batteries and Fuel cells. 3rd Edition, Edited by B. Reddy, McGraw Hill Book Company, N.Y.USA.
4. Viswanathan, B. and Scibioh, Aulice M, 2006, Fuel Cells, Principles and Applications. Universities Press.
5. Nick Yost, 2006, The Essential Hybrid Car Handbook: A Buyer's Guide. The Lyons Press, N.Y. USA.

ESE- HYDRO POWER PLANTS 3(2-1)

Learning Objectives:

To develop in the students the capability to understand, design, develop and implement hydro-power plants.

Contents:

General Introduction :- Hydropower potential, Concept of Modern Hydro Power Plant , Location /Site Selection, Plant Layout, Power Plant Safety , Reservoir, Dams & Tunnels etc. Constructional details and basic principles of Hydro-mechanical equipment, Hydrology & Hydro - Electric Power Plants- Hydrographs – Flow duration curve – Mass curve & storage. Site selection for hydroelectric power plants. Design Construction & Operation of Hydro-Electric Power Plants- Components-Advantages & Disadvantage of under-ground power station Turbine and auxiliaries, Construction and working principles of various types of Valves and Pumps and Hydraulic System. Construction and working principles of Alternators and Excitation Systems, Transformers, Motors, Switchgears. Operation, Control and Supervision of Hydro Power Plant. Instrumentation & Control (including DAS & DDC) and Protection system. Erection, Commissioning and Testing Aspects of Hydro Power Plant.

Micro-hydro power: Introduction, Present situation, Future potential and prospects, Constraints, Flow measurement, working principles of different types of turbines, details of the components of a micro-hydel power system, turbine selection criteria, site selection and feasibility study.

Practical:
The practical work will be based on Theory Work.

Suggested Readings:

1. Black and Veatch, “Power Plant Engineering”, ISBN 0-412-06401-4, CBS Publishers and Distributors, Chapter 23424.
2. S .Rao & Dr .B. B. Parulekar, “Energy Technology” , Third Edition, Khanna Publishers .

ESE- WIND ENERGY ENGINEERING 3(2-1)

Learning Objectives:

The study of this course will enable the students to design different types of wind turbines for power generation.

Contents:

General characteristics of wind resources, wind data analysis and resource estimation, wind turbine energy production estimation methods, Wind measurement and instrumentation, Principal Wind Turbine Components and their functions. Spacing of the Towers. Horizontal Axis Versus Vertical Axis wind turbines. One-dimensional Momentum Theory and the Betz Limit. Wake Rotation in HAWT, Aerodynamic of Horizontal Axis Wind Turbine- Airfoil Aerodynamics, flow over an Airfoil, Airfoil Behavior, Airfoil Flow Regime, Airfoil for Lift and Drag Machines. Blade design, Momentum and Blade Element Theory, Stresses due to Blade Weight and centrifugal force, Blade Natural Frequencies. Blade Shape for Ideal Rotor. Rotor Design: Basic Rotor Parameters, Blade Shape, Rotor Performance. Aerodynamic Control Options, Power Curve Prediction.
Aerodynamics of Vertical Axis Wind Turbines-Single Stream Tube Analysis, Multiple Stream Tube Momentum Theory, Aerodynamics of the Darrieus and Savonius Rotor, Environmental Aspects of Wind Turbines.

Practical:

The practical work will be based on Theory Work.

Suggested Readings:

1. Manwell, J.F, J.G. McGowan, A.L. Rogers 2009. Wind Energy Explained, Theory, design and application John. Wiley and Sons, U.K (2nd Ed.)
2. Tong, W. 2010. Wind Power Generation and Wind Turbine Design, WIT Press, USA.
3. S. Rao & B. B. Parulekar, 2005, Energy Technology. 4th edition, Khanna publishers.
4. Mukund. R. Patel, 2014, Wind and Solar Power Systems, 2nd Edition, Taylor & Francis.
5. L .L. Freris, 1990, Wind Energy Conversion Systems, Prentice Hall.
6. D. A. Spera, 2000, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press.

ESE- INSTRUMENTATION IN ENERGY SYSTEMS 3(2-1)

Learning Objectives:

This course will give acquaintance to the students about the use of instruments, data-logging for the performance evaluation of different energy systems.

Contents:
Measurement Errors - Materials, radiant storage- Transducer classification- Static and dynamic characteristics of transducers, Transient analysis of a control system. Temperature Measurement - Bimaterials, Pressure thermometers, Thermocouples, RTD, Thermisters, and Pyrometry, pyrometers- Calibration of Pressure measuring equipment. Flow Measurement- Variable head flow meters- Rota meters, Electromagnetic flow meters, Hot wire anemometers, Hot film transducers, Ultrasonic flow meters. Air pollution and Miscellaneous Measurements- Particulate sampling techniques, SO_2, Combustion Products, Opacity , odour measurements - Measurement of liquid level, Humidity, O_2, CO_2 in flue gases- pH measurement Moving Iron/coil, Energy measurement, power factor meter-Analog signal conditioning, Amplifiers, Instrumentation amplifier, A/D and D/A converters, Digital data processing and Data acquisition system.

Practical:
The practical work will be based on Theory Work.

Suggested Readings:

1. K. Sawhney, Puneet Sawney, 2002, A course in Mechanical Measurements and Instrumentation. Dhanpat Rai &Co.
2. Bechwith. Marangoni. Lienhard, 2000, Mechanical Measurements. 5th edition. Addison-Wesley.
3. J.P. Holman, 1994, Experimental methods for engineers. 6th edition, McGraw-Hill Co.

ESE- REFRIGERATION AND AIR CONDITIONING 3(2-1)

Learning Objectives:

To train the students about emerging technologies of refrigeration and air conditioning using conventional and solar thermal technologies

Contents:
Thermodynamic concepts, refrigeration cycles, air and vapor compression, characteristics of refrigerants, refrigeration systems, principles of operation and types of compressors, expansion devices, evaporators, condensers, Heat load estimation, psychometric analysis; design principle of cold storage, principles of air conditioning, methods of refrigeration. Determination of sensible and latent heat factor, , absorption and adsorption cycles, solid and liquid desiccant evaporative cooling systems, ejector cooling cycle, evaporative air cooling, Air-cycle steam jet. Refrigeration systems and their performances:, absorbers, cooling towers, fan coils, air-duct system, etc. Comfort factors-specifications –Limits for humidity, temperature etc., air distribution, ventilation, instrumentation. Alternate solar cooling systems

Practical:
The practical work will be based on Theory Work.

Suggested Readings:

1. Stoecker W.F. 1980, Refrigeration and Air Conditioning. TMH edition, McGraw Hill publication.
2. Ballaney P.L. 1980, Refrigeration and Air Conditioning. Khanna Publishers.
3. Trott A.R.1980, Refrigeration and Air Conditioning. 2nd Ed. Butterworth Publishers.

ESE- POWER ELECTRONICS AND MOTOR DRIVES 3(2-1)

Learning Objectives:

To train the students in the field the power electronics that will enable them to convert energy into different forms.

Contents:

Solid- State Devices, Latest development in the area of Power Electronics covering modern devices, converter topologies & control strategies.

Power Electronic Converters, Pulse width modulated rectifiers, Controlled rectifiers, single phase and three phase inverters, AC voltage controllers, DC-DC Converters, switch mode converters, Cyclo-converters, Matrix converters, Resonant and Soft-Switching Converters, High Frequency switching converters, State-space averaged modeling of power electronic converters. Power Factor analysis and instrumentation of power electronic converters, Brief description of some special applications of power electronic converters, Control Methods for Power Electronic Converters Sliding-Mode control of Power Converters, Fuzzy Logic and Neural Netrwork Control of Power Converters.
Solid State Drives, Motors operation on non-sinosoidal supply, **Closed loop control of solid state drives,** Inverter fed induction motor drives, **Cyclo-converter controlled AC drives, Chopper fed speed control of dc motor drives,** Speed control of Switched-reluctance motors, brushless dc motors, stepper motors using power electronic converters, **Brushless excitation of synchronous machines. Application of microprocessor, microcontroller, PLC in solid state drives**

Practical:

The practical work will be based on Theory Work.

Suggested Readings:

1. Rashid, M.H. 2011. Power Electronics Hand Book. McGrey Hill Co. Ltd.

2. Erickson, R.W. 2012. Fundamentals of Power Electronics, 2nd Ed. McGrey Hill Co. Ltd.
3. Dimal K.B. 2010. Power Electronics and Motor Drives:Advances and Trends.

ESE- ELECTRICAL POWER TRANSMISSION AND DISTRIBUTION 3(2-1)

Learning Objectives:

To enable the students to transmit electric power to the load center.

Contents:

Transmission system planning, Complex power in balanced three phase transmission lines. Power flow in transmission lines.

Performance Analysis of Transmission system - Transmission line constants, bundled conductors, Parallel lines, Steady state power limit and voltage regulation in Short transmission lines. Medium transmission line, A, B, C & D constants. Nominal π and nominal T circuits. Analysis of Long transmission lines, Line and load compensation, series and shunt compensation. Environmental effects of overhead lines.

Underground Cables - Types of underground cables, Cable installation techniques, Electric stress, dielectric constant, charging current, insulation resistance, skin effect and proximity effect, current carrying capacity of cables.

Distribution System Planning - Importance of distribution system planning, load forecasting. Factors affecting distribution system planning, planning methods, computer applications, distribution automation and control, Distribution system in Pakistan, Planning constraints in Pakistan

Distribution Substation - Distribution substation, Substation bus schemes. Rating of Distribution substation, limitation of service area. Square and hexagonal service area. Distribution transformer, distribution transformer efficiency, parallel operation of transformers, vector groups

Design Considerations for Primary and Secondary Distribution Systems - Primary distribution feeders, Primary feeder voltage level and loading, Design considerations for Radial feeders, Economic design of secondary lines, voltage fluctuation. Voltage regulation, Distribution system voltage control, line drop compensator.

Practical:

The practical work will be based on Theory Work.

Suggested Readings:

1. Goran, T. 2014. Electrical Power transmission System Engineering, 3rd Ed.

2. Grainger J.J, Willam D. Stevension, W.D 2010. Power System analysis.
3. Stevenson W.D. 1982. Elements of Power System.

ESE- ENERGY SYSTEMS MODELLING AND SIMULATION 3(2-1)

Learning Objectives:
To impart knowledge regarding mathematical modeling and simulation of Energy System

Contents:
Introduction to energy systems modeling and simulation; Importance of modeling and simulation in energy systems; Modeling overview - steps in model development; Nature of Energy Systems Models and Analysis- Response of Energy Systems and their Analysis; Quantitative techniques: Interpolation - polynomial, Lagrangian; Curve fitting; Regression analysis; Solution of transcendental equations; Systems simulation - information flow diagram, Optimization: objectives/constraints, problem formulation; Linear programming - simplex tableau, pivoting, sensitivity analysis, Dynamic programming, Search techniques- univariate/multivariate; Dealing with uncertainty - probabilistic techniques; Pinch analysis; Energy-Economy Models: Scenario generation, Input-Output Models, Numerical solution of differential equations; Transit analysis; Analytics of System Data- Modeling of electrical machines/loads- Modeling of the grid synchronization and modulation techniques- Smart Grid modeling. Energy Modeling Tools.

Practical:
The practical work will be based on Theory Work.

Suggested Readings:

1. Frank L. Severance, 2004, System Modeling and Simulation-An Introduction. John Wiley and Sons.
2. Philip D. Cha, James J. Rosenberg, Clive L. Dym, 2000, Fundamentals of Modeling and Analyzing Engineering Systems. Cambridge University Press.
3. Averaill M. Law and W. David Kelton, 2004, Simulation Modeling and Analysis.
4. Ferrarini, L., Veber, C. 1998, Modeling, Control, Simulation and Diagnosis of Complex Industrial and Energy Systems.

ESE- ADVANCED CLEAN COAL TECHNOLOGIES 3(2-1)

Learning Objectives:
To impart knowledge regarding Coal as an important source for Energy and its utilization for energy conversion system.

Contents:

Introduction to clean coal technologies, Coal reserves and its uses. Direct and indirect coal liquefaction-process description, parameters, catalyst preparation, characterization, Hydrocracking/ Hydrotreating reaction mechanism and kinetics, Single stage and two stage liquefaction, catalytic reactors system. FT reactor overview, Reaction mechanism, kinetics Syn gas production and composition, syn gas purification, and process parameters, Energy analysis/ Heat exchanger network optimization in FT synthesis, Products refinery Products analysis, and health safety and Environmental considerations. Hybrid approach to synthesize liquid fuels, Comparison of ICL and DCL, Hybrid approach description/ Process flow diagrams.
Clean coal gasification - process description, coal preparation, gasifier design, reaction kinetics, gas cleaning. Integrated Gasification Combine cycle (IGCC) - process description, thermodynamic cycle, CO_2 pre combustion capture and storage, Energy requirements.
Underground coal gasification (UCG) - overview, important geological aspects for design consideration, Channel formation b/w injection and production wells, Process parameters/Coal and Rock properties, Economics consideration.
Carbon capture techniques, Power Generation technologies incorporating CO_2 Capture, CO_2 Capture Chemical Processes.

Practical:

The practical work will be based on Theory Work.

Suggested Readings:

1. Bruce G. Miller, (latest edition), Clean Coal Engineering Technology.
2. Paul W. Spaite, 2000, Emerging clean coal technologies.
3. David A. Bell, Brian F. Towler, 2002, Coal Gasification and its Applications.

ESE- COMBUSTION AND POLLUTION CONTROL 3(2-1)

Learning Objectives:
To provide an understanding of the fundamentals of combustion and the formation and control of pollution including current /International regulations relating to this.

Contents:
Fundamentals of combustion principles, Theoretical and actual combustion processes, Combustion chemistry, combustion thermodynamics, combustion stoichiometry, chemical equilibrium, flame types and properties, fossil fuel utilization and combustion mechanism, biomass combustion and co-firing, formation and control of combustion pollutants.

Current National and international regulations related to air pollution and combustion generated pollutants. Global, regional and local environmental issues.
Design and sizing of environment pollution control technologies; Simulation of environmental systems; Environmental impact assessment of energy projects; Environmental management, Environmental health and safety; Legal and economic tools for energy/environmental policies including international agreements and programs as well as economic mechanism.

Practical:

The practical work will be based on Theory Work.

Suggested Readings:

1. Stephen R. Turns, 2004, An Introduction to Combustion: Concepts and Applications. McGraw Hill Co. Ltd.
2. Gary L Borman, Keneth W Ragland, 2002, Combustion Engineering. McGraw Hill Co. Ltd.
3. Joseph A. Salvateo, Nelson L. Nemerow, Franklin J Agarady, 2004, Environmental Engineering.
4. S.S Dara (latest edition), Environmental Chemistry and pollution Control.

ESE- ENERGY MANAGEMENT IN BUILDINGS 3(2-1)

Learning Objectives:
To enable students to gain essential practical understanding of energy systems in buildings
Contents:

Processes in Building; Indoor Activities and Environmental Control, Internal and External Factors on Energy Use and the Attributes of the Factors, Characteristics of Energy Use and Its Management, Macro Aspect of Energy Use in Dwellings and Its Implications
Indoor Environmental Requirement and Management; Thermal Comfort, Ventilation and Air Quality, Air-conditioning Requirement, Visual Perception, Illumination Requirement, Auditory Requirement
Climate, Solar Radiation and Their Influences; The Sun-earth Relationship and the Energy Balance on the Earth's Surface, Climate, Wind, Solar Radiation, and Temperature, Sun Shading and Solar Radiation on Surfaces, Energy Impact on the Shape and Orientation of Buildings
End-use Energy Utilization and Requirements; Lighting and Daylighting, End-use Energy Requirements, Status of Energy use in Buildings, Estimation of Energy Use in a Building

Heat Gain and Thermal Performance of Building Envelope Steady and No steady Heat Transfer Through the Glazed Window and the Wall, Standards for Thermal Performance of Building Envelope, Evaluation of the Overall Thermal Transfer

Non-Steady Heat and Moisture Gain through Building Envelope; Single and Multi-Dimensional Problems, Transfer Function and Finite-Difference Solution, Energy Balance Concept and its Implementation

Technologies for Low Energy Buildings; Application of Radiant Barriers With other Building Materials, Solar-Generated Desiccant Dehumidification for Ventilation, Radiant Panel Cooling, Natural and Active Cooling with Adaptive Comfort, Daylighting Application

Heat Gain Through Window; Solar Radiation Transmission through Complex Fenestration System, Thermal Gain and Net Heat Gain, Methods of Control

Dynamic Air-Conditioning Load; Dynamic and Latent Heat Gain from External and Internal Source by Air, Cooling Coil Load and Air-Conditioning Load

Energy Prediction; Prediction of Energy Use by Simple Indicators and by Building Energy Simulation, Application of Neural Network for Energy Prediction

Practical:

The practical work will be based on Theory Work.

Suggested Readings:

1. J. Krieder, and A. Rabl, Heating and Cooling of Buildings: Design for Efficiency. McGraws-Hill Publishers.
2. S. M. Guinnes, and Reynolds, Mechanical and Electrical Equipment for Buildings. John Wiley and Sons.
3. Alexander Shaw, Energy Design for Architects. AEE Energy Books.
4. B. Agrawal and G. N. Tiwari. Building Integrated Photovoltaic Thermal Systems For Sustainable Developments.

ESE- SOLAR PHOTOVOLTAIC SYSTEMS 3(2-1)

Learning objective:

To learn about solar photovoltaic system components, types, design and performance measurement.

Contents:

An introduction to Photovoltaics, the physics behind the technology, the devices and practical applications, Photovoltaic cells, semiconductor physics, solar cell structures, their principle of operation, design and

fabrication. Photovoltaic systems including power converters and energy storage, residential grid-connected photovoltaic systems.
Solar PV system components, types and characteristics, Solar cells type, characteristics and configurations, solar charge controllers, types, characteristics, solar inverters type and characteristics', Solar cables, solar mounting system, solar PV system types; Solar PV off grid, hybrid and on grid systems. Solar photovoltaic applications, solar system performance measurement and monitoring, solar system operation and maintenance.

Practical:
The practical work will be based on Theory Work.

Suggested Readings:

1. Duffie, J.A and W. A. Beckman 2009. Solar Engineering of Thermal Processes.
2. Goswami, Y., F. Kreith and J. F. Kreider (latest edition). Principles of Solar Engineering.
3. Kalogirou, S.A. (latest edition). Solar Energy Engineering: Processes and Systems.
4. Wenham, S.R. and M. A. Green and M. E. Wat (lat. Ed) Applied Photovoltaics.
5. Green, M.A. Solar Cells: Operating Principles, Technology and System Applications.
6. Lorenzo, E., G. Araujo, A. Cuevas. (Latest edition). Solar Electricity: Engineering of Photovoltaic Systems.

ESE- BIOFUELS ENGINEERING 3(2-1)

Learning Objectives:

To impart sound knowledge in bio-fuels feed stock, production and processing.

Contents:

Process Machinery-pumps, valves, heat exchangers, cooling towers, centrifuges, compressors, thermal oxidizers, distillation towers, compressors, refrigeration principles and boiler systems. Startup, shutdown, operation and troubleshooting.
Instrumentation and Control-.P& ID terminologies with applied applications, sequence of operation, including residence time, pressures, and temperature seen in various stages of production. Complete design calculations for equilibrium staged separation processes (e.g. distillation, absorption, solvent extraction). Mass transfer fundamentals.
Biodiesel Technologies and Regulatory Issues-Investigates the underlying research and reaction processes that are used to produce biodiesel.

Studying feedstock options coupled with past and present technologies provides foundational knowledge about the industry. In-depth review of the ASTM Standards for biodiesel and the regularity issues.
Biodiesel Processes Analysis: Overall process of biodiesel production, review of biodiesel chemistry, process engineering, post reaction processing, fuel specification and properties.
Reaction Kinetics and Reactor Design: Kinetic data, determination of rate laws, analysis of complex reaction networks and design of ideal isothermal reactors. Analyze data for heterogeneous catalytic reactions. Design reactor systems for given synthesis with special emphasis on trans-esterification and bio-fermentation feedstock preparation, treatment and recovery of side streams, fuel transportation storage and general plant operations.
Ethanol Process and Separation Technology- Fundamentals process of ethanol production. A process flow Diagram (PFD) of a typical ethanol plant, operation, including residence time, pressures, and the temperatures, Rationale for feedstock and additives used in ethanol processing as well as product and co-product production and use, basic principles of ethanol distillation, evaporation, and dehydration, operating components in a distillation system

Practical:
The practical work will be based on Theory Work.

Suggested Readings:

1. Caye M. Dramcho, Nighiem Phu Nhuan, Terry H. Walker. Biofuels Engineering Process Technology.
2. Harry Sila. Chemical Process Engineering Design and Economics.
3. George F. Baumiester. Standard Hand book for mechanical Engineering.
4. Pimentel D. (2008). Biofuels, Solar, and Wind as Renewable Energy Systems. Springer Verlag.
5. Drapcho, C. M.; Nhuan, N.P.; and T. H. Walker 2008. Biofuels Engineering Process Technology. MC Graw Hill, New York.
6. Hiller E. A., and B. A. Stout. Biomass Energy: A Monograph. Texas A&M University Press, College Station, Texas.
7. Mehla S. K. 2008. Biofuels: Marketing Strategies and Impact on Rural Development. Aavishkar Publishers, and Distributers, Jaipur, India.

NUCLEAR POWER PLANT ENGINEERING 3(3-0)

Learning objective:

Students will learn nuclear power plants layout, its components, design, and protection, implementation and performance analysis.

Contents:

Nuclear Reaction, Fission and Fusion Reaction, Critical Mass Chain Reaction, Moderators, Reactor Control and Cooling, Classification of Reactors, Different Types of Reactors, Radiation Damages, Shielding of Grays Neutrons, Materials For Construction. Thermoelectric Generators: Thermoelectric Effect, Solid State Description of Thermoelectric Effect Analysis and Design of Thermoelectric Generator, Figure of Merit, Device Configuration, Solar and Radioisotope Powered Generators, Applications. Layout of nuclear power plants; Containment buildings; Primary containment vessels; Structure of reactor core; and mechanical stress in various structures. Description and analysis of power plant systems and components including steam generator, steam dryer and separator, pressurizer, re-heater, heat exchanger, condenser, demineralizer, pumps ,turbine, generator, cooling tower; Auxiliary cooling systems. Fuel handling mechanisms; Control and mechanisms; Rad waste systems; Electrical Systems;

Reactor grid interface and load following. Basic considerations in nuclear plant design; Components of nuclear power cost; Economic comparison of nuclear and fossil fueled plants; Dual and multipurpose nuclear plants; Future trends in nuclear power cost. Thermoelectric Generators:

Suggested Readings:

1. Rust, J. H. 1979. Nuclear Power Plant Engineering. Haralson.
2. El-Wakil, M.M. 1982. Nuclear Energy Conversion. International Text Book.
3. Pedersen, E.S. 1978. Nuclear Power. Ann Arbor Science.
4. El-Wakil, M.M. 1984. Power Plant Technology. McGraw-Hill Publishing Co. Ltd.
5. Lish, K.C. 1972. Nuclear Power Plant Systems & Equipment. Industrial Press Inc.

DEVELOPMENT AND EVALUATION OF ENERGY PROJECTS 3(3-0)

Course Objectives:

Understanding the project cycle is important because of lumpy nature of most energy projects and their wide socio-economic and environmental impacts. Its importance has increased in the era of deregulated and privatized energy industries, and in view of global concern about sustainable development of energy projects. The main objective of this course is to provide a comprehensive understanding of the concepts and methodologies for project identification, project preparation, project evaluation and project financing.

Course Outline:

Introduction to energy projects

1. Features of energy projects

2. Project cycle
3. Context of energy projects

Project preparation and Development

1. Project Identification
2. Project proposal preparation
3. Pre-feasibility and Feasibility studies
4. Budgeting
5. Project approval and implementation

Cost concepts and financial calculations

1. Cost concepts
2. Time value of money
3. Interest formulas and equivalence
4. Inflation
5. Depreciation

Economic evaluation of energy projects

1. Alternative methods of project evaluation
2. Economic vs. financial evaluation
3. Valuation of costs and benefits
4. Sensitivity analysis and break-even analysis

Financial evaluation of projects

1. Elements of financial costs
2. Financial structure and project feasibility
3. Revenue streams: Effects of assumptions and pricing
4. Sensitivity analysis

Environmental Issues in energy projects

1. Evaluation of Environmental Impacts
2. Methods of Economic Evaluation of Environmental Impacts
3. Effects of Environmental Regulations in Project Evaluation

Financing of energy projects

1. Sources of funds and the cost of capital
2. Project financing
3. Raising funds in the international market

Risk analysis in project development

1. Origins of project risk

2. Methods of describing project risk
3. Measurement of investment worth under risk

Life cycle analysis (LCA) of energy projects

1. Life cycle cost analysis
2. Other aspects of life cycle analysis
3. LCA applications in energy projects

Development of projects under Clean Development Mechanism

1. Prerequisites of a CDM project
2. CDM project cycle
3. Estimation of baseline GHG emissions and certified emission reductions
4. Financial Valuation of a CDM project
5. Carbon market and financing issues in CDM projects

Books

1. Park, C.S. Contemporary Engineering Economics. Pearson; 6 edition (April 30, 2015).

2. Khatib, H. Economic Evaluation of Projects in the Electricity Supply Industry. The Institution of Engineering and Technology; 3 edition (March 4, 2014*).*
3. ADB Guidelines for the Economic Analysis of Projects Asian Development Bank
4. Markus Burger. *Managing Energy Risk: An Integrated View on Power and Other Energy Markets. Wiley; 1 edition (December 17, 2007)*

COMPUTER APPLICATIONS IN ENERGY SYSTEMS 3(3-0)

Course Objectives:

The primary objectives of this course are to familiarize students with practical applications of soft wares used to model various aspects of energy systems ranging from energy planning strategies, carbon mitigation technologies, energy production & life cycle cost, grid design, evaluate supply & demand, depicting all possible flows to energy from resource extraction, through energy transformation and end-use devices, to demand for useful energy services.

Contents:

HOMER

HOMER models a wide range of conventional and renewable energy technologies. Power sources that can be modeled include: solar photovoltaics (PV), wind turbines, run-of-river hydro power, diesel,

gasoline, biogas, alternative, co-fired and custom-fueled generators, electric utility grids, microturbines, and fuel cells. Storage options include: battery banks and hydrogen.

LEAP

LEAP is a comprehensive integrated scenario-based energy-environment modeling tool. Its scenarios account for how energy is consumed, converted and produced in a given energy system under a range of alternative assumptions on population, economic development, technology, price and so on. It is notable for its flexibility, transparency and user-friendliness.

GEMIS

GEMIS is the acronym for the Global Emission Model for Integrated Systems. GEMIS performs full life-cycle computations for a variety of fuel chains, calculating emissions, resource use and costs.

Energy Costing Tool

In recognition of the critical role that energy plays in reaching the MDGs, UNDP's Sustainable Energy Programme has developed a set of tools for helping mainstream energy considerations into MDG-based national development strategies. A crucial part of developing MDG-based national development strategies is MDG costing, which quantifies the specific financial and human resources needed, as well as infrastructure required, to meet the MDGs.

Energy PLAN

EnergyPLAN is a Windows-based tool created to assist in the design of national or regional energy planning strategies. It is a deterministic input/output model. General inputs are demands, renewable energy sources, energy station capacities, costs and a number of optional different regulation strategies emphasizing import/export and excess electricity production.

CO2DB

CO2DB is a database containing detailed data on carbon mitigation technologies. The database currently contains approximately 3000 technologies, including detailed technical, economic and environmental characteristics as well as data on innovation, commercialization and diffusion.

RETSCREEN

RETScreen International Clean Energy Project Analysis Software can be used world-wide to evaluate the energy production, life-cycle costs and greenhouse gas emission reductions for various types of energy efficient and renewable energy technologies (RETs). The software also includes product, cost and weather databases, and a detailed online user manual.

ENPEP

The Energy and Power Evaluation Program (ENPEP) is a set of ten energy, environmental, and economic analysis tools. ENPEP is developed by the U.S. Argonne National Laboratory with support from the U.S. Department of Energy. Several ENPEP modules are developed by

and are the property of the International Atomic Energy Agency (IAEA). ENPEP can be used to evaluate the entire energy system (supply and demand side), perform a detailed analysis of the electric power system, and evaluate environmental implications of different energy strategies. Each module has automated linkages to other ENPEP modules as well as stand-alone capabilities. ENPEP consists of the following modules:

- MACRO-E: A macro-economic tool that helps analyze the feedbacks between the energy sector and the economy as a whole.
- MAED:: An MS-Excel-based bottom-up energy demand analysis model.
- LOAD: which analyzes hourly electric loads and generates load duration curves for use in other ENPEP modules.
- PC-VALORAGUA: used to determine the optimal generating mix of hydro and thermal electric power systems.
- WASP-IV: used to determine least-cost generating system expansion paths subject to user-defined constraints.
- GTMax: used to study marketing and system operational issues deregulated energy markets.
- ICARUS: used to assess the reliability and economic performance of alternative expansion plans for electric utility generating systems.
- IMPACTS: estimates physical and economic damages from air pollution.
- BALANCE: uses a market-based simulation approach to examine how various segments of the energy system will respond to changes in energy prices and demands.

Books:

1. Kimio Uno. Economy-Energy-Environment Simulation Beyond the Kyoto Protocol. Dordrecht ; Boston : Kluwer Academic Publishers, c2002.
2. **Brain J. Thomson Energy,simulation-training, ocean engineering, and instrumentation. Univ of Rochester Pr (June 1, 2001).**
3. **Albert Thumann, William J. Younger, Terry Niehus Handbook of Energy Audits. Fairmont Press; 9 edition (November 7, 2012).**

FLUID FLOW AND HEAT TRANSFER 3(2-1)

Learning Objectives:

After studying the course, student should have understanding of advanced heat and fluid flow processes and their role in modern methods of power generation; in-depth understanding of numerical and experimental techniques in heat and fluid flow.

Contents:

Fluid Mechanics - Fluid properties, Fluid classification, Kinematics and

Dynamics of fluid, fundamental techniques of computational fluid dynamics, Navier-Stokes equations for viscous flow, Mass, momentum and energy conservation equations, Boundary layer and Potential flow, Laminar and turbulent Boundary layers, NS equation applied to Boundary layer and potential flow, Numerical solutions and convergence criteria, Grid generation, discretization methods, turbulence modeling.
Heat Transfer - Specific heat, work and heat transfer, Heat conduction, heat exchangers, steady and unsteady heat conduction, convection, convection heat transfer co-efficient, free and forced convection, radiation properties (Absorptance, Transmittance and Reflectance), black body radiation, shape factor and view factors, solar radiation,

Practical:

The practical work will be based on Theory Work.

Suggested Readings:

1. H. K. Versteeg and W. Malalasekera, 2001, An Introduction to Computational Fluid Dynamics.
2. K. Murlidhar and G. Biswas, 2000, Advanced Fluid Mechanics.
3. Suhas V. Patanker, 2004, Numerical Heat Transfer and Fluid Flow.
4. Yunus Cengel, 2002, Heat and Mass Transfer. McGraw Hill Publishing Co. Pvt. Ltd.

ANNEXURE - A

DETAILS OF COMPULSORY COURSES
COMPULSORY COURSES IN ENGLISH FOR
Undergraduate Level

English I (Functional English) **Credit Hrs. 3**

Objectives: Enhance language skills and develop critical thinking.

Course Contents

Basics of Grammar
Parts of speech and use of articles
Sentence structure, active and passive voice
Practice in unified sentence
Analysis of phrase, clause and sentence structure
Transitive and intransitive verbs
Punctuation and spelling

Comprehension
Answers to questions on a given text

Discussion
General topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

Listening
To be improved by showing documentaries/films carefully selected by subject teachers

Translation skills
Urdu to English

Paragraph writing
Topics to be chosen at the discretion of the teacher

Presentation skills
Introduction

Note: Extensive reading is required for vocabulary building

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)
- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)
- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Recommended Books:

1. **Functional English**

a) Grammar
   1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 1. Third edition. Oxford University Press. 1997. ISBN 0194313492
   2. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0194313506

b) Writing
   1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.

c) Reading/Comprehension
   1. Reading. Upper Intermediate. Brain Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.

d) Speaking

English II (Communication Skills) **Credit Hrs. 3**

Objectives: Enable the students to meet their real life communication needs.

Course Contents

Paragraph writing

Practice in writing a good, unified and coherent paragraph

Essay writing

Introduction

CV and job application
Translation skills
Urdu to English

Study skills
Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension

Academic skills
Letter/memo writing, minutes of meetings, use of library and internet

Presentation skills
Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)
- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)
- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Recommended Books:

Communication Skills

a) Grammar
   1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.

b) Writing
   1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).

2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).

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

English III (Technical Writing and Presentation Skills)
Credit Hrs.3

Objectives: Enhance language skills and develop critical thinking

Course Contents:

Presentation skills

Essay writing
Descriptive, narrative, discursive, argumentative

Academic writing
How to write a proposal for research paper/term paper

How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency)

Technical Report writing

Progress report writing

Note: Extensive reading is required for vocabulary building

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)
- Written (Long Questions, Short Questions, MCQs)
- Presentation

- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Recommended Books:

Technical Writing and Presentation Skills

a) Essay Writing and Academic Writing
   1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).

   2. College Writing Skills by John Langan. McGraw-Hill Higher Education. 2004.
   3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.

b) Presentation Skills

c) Reading
   The Mercury Reader. A Custom Publication. Compiled by northern Illinois University. General Editiors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharton. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

ANNEXURE - B

ISLAMIC STUDIES
(Compulsory)

Objectives:

This course is aimed at:

1 To provide Basic information about Islamic Studies
2 To enhance understanding of the students regarding Islamic Civilization
3 To improve Students skill to perform prayers and other worships
4 To enhance the skill of the students for understanding of issues related to faith and religious life.

Detail of Courses:

Introduction to Quranic Studies

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

Study of Selected Text of Holly Quran

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

Study of Selected Text of Holly Quran

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

Seerat of Holy Prophet (S.A.W) I

1) Life of Muhammad Bin Abdullah (before Prophet Hood)
2) Life of Holy Prophet (S.A.W) in Makkah
3) Important Lessons Derived from the life of Holy Prophet in Makkah

Seerat of Holy Prophet (S.A.W) II

1) Life of Holy Prophet (S.A.W) in Madina
2) Important Events of Life of Holy Prophet in Madina
3) Important Lessons Derived from the life of Holy Prophet in Madina

Introduction to Sunnah

1) Basic Concepts of Hadith
2) History of Hadith
3) Kinds of Hadith
4) Uloom –ul-Hadith
5) Sunnah & Hadith
6) Legal Position of Sunnah

Selected Study from Text of Hadith

Introduction to Islamic Law & Jurisprudence

1) Basic Concepts of Islamic Law & Jurisprudence
2) History & Importance of Islamic Law & Jurisprudence
3) Sources of Islamic Law & Jurisprudence
4) Nature of Differences in Islamic Law
5) Islam and Sectarianism

Islamic Culture & Civilization

1) Basic Concepts of Islamic Culture & Civilization
2) Historical Development of Islamic Culture & Civilization
3) Characteristics of Islamic Culture & Civilization
4) Islamic Culture & Civilization and Contemporary Issues

Islam & Science

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

Islamic Economic System

1) Basic Concepts of Islamic Economic System
2) Means of Distribution of wealth in Islamic Economics
3) Islamic Concept of Riba
4) Islamic Ways of Trade & Commerce

Political System of Islam

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

Islamic History

1) Period of Khlaft-E-Rashida
2) Period of Ummayyads
3) Period of Abbasids

Social System of Islam

1) Basic Concepts of Social System of Islam
2) Elements of Family
3) Ethical Values of Islam

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Reference Books:

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

ANNEXURE - C

Pakistan Studies (Compulsory)

Introduction/Objectives

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

Course Outline

1. **Historical Perspective**
   a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah.
   b. Factors leading to Muslim separatism
   c. People and Land
      i. Indus Civilization
      ii. Muslim advent
      iii. Location and geo-physical features.

2. **Government and Politics in Pakistan**
   Political and constitutional phases:
   a. 1947-58
   b. 1958-71
   c. 1971-77
   d. 1977-88
   e. 1988-99
   f. 1999 onward
3. **Contemporary Pakistan**
   a. Economic institutions and issues
   b. Society and social structure
   c. Ethnicity
   d. Foreign policy of Pakistan and challenges
   e. Futuristic outlook of Pakistan

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation

- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Books Recommended

1. Burki, Shahid Javed. *State & Society in Pakistan,* The Macmillan Press Ltd 1980.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy.* Karachi: Oxford University Press, 2000.
3. S.M. Burke and Lawrence Ziring. Pakistan's Foreign policy: An Historical analysis. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. *Pakistan Political Roots & Development.* Lahore, 1994.
5. Wilcox, Wayne. *The Emergence of Bangladesh.,* Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. *Pakistan Kayyun Toota,* Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
7. Amin, Tahir. *Ethno - National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development.* Kent England: WmDawson & sons Ltd, 1980.
9. Zahid, Ansar. *History & Culture of Sindh.* Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan,* Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan.* Boston: Houghton Mifflin, 1967.
12. Aziz, K.K. *Party, Politics in Pakistan,* Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, Pakistan Under Martial Law, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective.* Islamabad: National Commission on Historical and Cultural Research, 1993.

ANNEXURE - D

COMPULSORY MATHEMATICS
COURSES FOR BSc (Hons) AGRICULTURE

1. MATHEMATICS I (ALGEBRA)

Prerequisite(s): Mathematics at secondary level

Credit Hours: 3 + 0

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

Course Outline:
Preliminaries: Real-number system, complex numbers, introduction to sets, set operations, functions, types of functions.

Matrices: Introduction to matrices, types, matrix inverse, determinants, system of linear equations, Cramer's rule.

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

Sequences and Series: Arithmetic progression, geometric progression, harmonic progression.

Binomial Theorem: Introduction to mathematical induction, binomial theorem with rational and irrational indices.

Trigonometry: Fundamentals of trigonometry, trigonometric identities.

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)
- Written (Long Questions, Short Questions, MCQs)
- Presentation

- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Recommended Books:

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

2. MATHEMATICS II (CALCULUS)

Prerequisite(s): Mathematics I (Algebra)

Credit Hours: 3 + 0

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

Course Outline:
Preliminaries: Real-number line, functions and their graphs, solution of equations involving absolute values, inequalities.

Limits and Continuity: Limit of a function, left-hand and right-hand limits, continuity, continuous functions.

Derivatives and their Applications: Differentiable functions, differentiation of polynomial, rational and transcendental functions, derivatives.
Integration and Definite Integrals: Techniques of evaluating indefinite integrals, integration by substitution, integration by parts, change of variables in indefinite integrals.

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)
- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)
- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Recommended Books:
Anton H, Bevens I, Davis S, *Calculus: A New Horizon* (8th edition), 2005, John Wiley & Sons, New York.
Stewart J, *Calculus* (3rd edition), 1995, Brooks/Cole (suggested text)
Swokowski EW, *Calculus and Analytic Geometry*, 1983, PWS-Kent Company, Boston.

Thomas GB, Finney AR, *Calculus* (11th edition), 2005, Addison-Wesley, Reading, Ma, USA.

3. MATHEMATICS III (GEOMETRY)

Prerequisite (s): Mathematics II (Calculus)

Credit Hours: 3 + 0

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

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

Circle: Equation of a circle, circles determined by various conditions, intersection of lines and circles, locus of a point in various conditions.
Conic Sections: Parabola, ellipse, hyperbola, the general-second-degree equation.

Teaching Methodology
- Lecturing
- Written Assignments

Assessment

Mid Term (40%)
- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)
- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Recommended Books:
Abraham S, Analytic Geometry, Scott, Freshman and Company, 1969
Kaufmann JE, College *Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston.
Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6th edition), 1986, PWS-Kent Company, Boston.

Note:

1. ***Two courses will be selected from the following three courses of Mathematics.***
2. ***Universities may make necessary changes in the courses according to the requirement as decided by the Board of Studies.***

ANNEXURE - E

Statistics-I

Credit 3 (2-1)

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

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

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

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

Practical

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

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

B**ook Recommended**

1. Introduction to Statistical Theory Part- I by Sher Muhammad and Dr. Shahid Kamal (Latest Edition)

2. Statistical Methods and Data Analysis by Dr. Faquir Muhammad
3. A. Concise Course in A. Level Statistic with world examples by J. Crawshaw and J. Chambers (1994)
4. Basic Statistics an Inferential Approach 2nd Ed. (1986) Fran II. Dietrich-II and Thomes J. Keans

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

Sampling Probability and non-Probability Sampling, Simple random sampling stratified random sampling Systematic sampling error, Sampling distribution of mean and difference between two means. Interference Theory: Estimation and testing of hypothesis, Type—I and type-II error, Testing of hypothesis about mean and difference between two means using Z-test and t-test, Paired t-test, Test of association of attributes using X2 (chi-square) Testing hypothesis about variance.

Practicals

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

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Book Recommended

1. Muhammad, S. and Kamal S. Introduction to Statistical Theory Part-II (Latest Edition).

2. Muhammad F. Statistical Methods and Data Analysis
3. Steal, G. D, and Tarric, J. H. 1980. Principles and Procedures of Statistics A Bio-material approach, 2nd Edition.
4. Gomez K. A. and Gomez, A. A. 1980. Statistical Procedures for Agricultural Research 2nd Edition.

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

ANNEXURE - F

Course Name: **Introduction to Information and Communication Technologies**

Course Structure: Lectures: 2 Labs: 1 **Credit Hours:** 3

Pre-requisite: None **Semester: 1**

Course Description:
This is an introductory course on Information and Communication Technologies. Topics include ICT terminologies, hardware and software components, the internet and world wide web, and ICT based applications. After completing this course, a student will be able to:

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

Course Contents:

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

Teaching Methodology

- Lecturing

- Written Assignments

Assessment

Mid Term (40%)
- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)
- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Text Books/Reference Books:

1. Norton, P. Introduction to Computers. 6th International Edition (McGraw-Hill)
2. Sawyer, W. Using Information Technology: A Practical Introduction to Computer & Communications, 6th Edition (McGraw-Hill).
3. Hutchinson, S. E. Computers, Communications & information: A user's introduction.
   Leon, A. Fundamentals of Information Technology. Mathewsleon Leon Press.

ANNEXURE - G

Functional Biology-I Credit Hours 3+0

Biological Methods

Principles of Cellular Life
Chemical Basis
Structure and Function
Principles of Metabolism
Energy Acquisition
Principles of Inheritance
Mitosis and Meiosis
Chromosomes
Observable Inheritance Patterns
DNA Structure and Function
RNA and Proteins
Genes
Genetic Engineering and Biotechnology
Biodiversity
Fundamental Concept of Biodiversity
One or two examples of each of the following from commonly found organism
Prions
Viruses
Bacteria
Protistans
Algae
Fungi
Plants
Crops
Animals
Invertebrates
Vertebrates

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)

- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Reading

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

Functional Biology-II Credit Hours 3+0

Myths and Realities of Evolution

Microevolution
Speciation
Macroevolution

Level of Organization
Plants
- Tissues
- Nutrition and Transport
- Reproduction
- Growth and Development

Animals
- Tissue, Organ System and Homeostasis
- Information Flow and Neuron
- Nervous System
- Circulation and Immunity
- Nutrition and Respiration
- Reproduction and Development

Ecology and Behavior
- Ecosystems
- Biosphere
- Social Interactions
- Community Interactions
- Human Impact on Biosphere
- Environment Conservation

Teaching Methodology

- Lecturing
- Written Assignments

Assessment

Mid Term (40%)
- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Final Term (60%)
- Written (Long Questions, Short Questions, MCQs)
- Presentation
- Assignments

Reading

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

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

General Recommendations

The committee recommended the following:

1. Department of Crop Physiology be established at PMAS Arid Agriculture University, Rawalpindi, Khyber Pakhtunkhwa Agriculture University, Peshawar, Gomal University, D.I. Khan, Balochistan University of Information Technology Engineering and Management Sciences, (BUITEMS) Quetta, Bahauddin Zakariya University, (BZU) Multan, The Islamia University of Bahawalpur, Lasbela, University of Agriculture, Water and Marine Sciences Uthal and The University of Azad Jamu and Kashmir, Rawlakot Campus like Sindh Agriculture University, Tandojam and University of Agriculture, Faisalabad where this department has already been established.
2. Crop physiology course may be added in agriculture domain and meetings of NCRC in Crop Physiology may be arranged in the series of agriculture domain subjects.
3. Teacher trainings be arranged to acquire new techniques in crop physiology.
4. Adequate number of posts of Crop Physiologists be created in agricultural departments/organizations of the country to strengthen the agricultural system by giving due recognition to this important field.
5. The committee further recommended that Crop Physiology be given an equivalent status as other major disciplines of agricultural specialization (e.g. Agronomy, Soil Science etc.) by the Federal and Provincial Governments to include this field of specialization in subject of preference.
6. National Book Foundation of Pakistan may be requested to print relevant text books in Crop Physiology in consultation with the experts.
7. Due recognition/incentive in the form of impact factor be given to the authors by Higher Education Commission for writing book/book chapter/manual.
8. The Society of Crop Physiologists needs to be established and later on a Journal of Crop Physiology may be published.
9. Internship:
    a) Last six-months/final semester of the academic program should preferably be reserved for internship. However, where internship opportunities are not available, optional courses should be offered as an alternative.
    b) HEC should provide remuneration @ Rs.15000/month/internee for the internship.