Minutes of the 29th
Special Meeting of the Board of Studies
Faculty of Engineering Sciences
held on
9th June 2023
through Microsoft Teams

Bahria University Islamabad

Contents

Minutes of the 29th Special Meeting of Faculty Board of Studies Engineering Sciences held on 9th June, 2023 through Microsoft Teams

Attendance:

BUIC		
Snr. Prof. Dr. Atif Raza Jafri	Dean ES	Chair
Snr. Assoc. Prof. Dr. Said Akbar Khan	HoD(E&ES)	Member
Snr. Assoc. Prof. Dr. Arif ur Rehman	HoD(CS)	Member
Snr. Assoc. Prof. Dr. Awais Majeed	HoD(SE)	Member
Assoc. Prof. Dr. Shahzad Ahmed	HoD(CE)	Member
Assoc. Prof. Dr. Junaid Imtiaz	HoD(EE)	Member
BUKC		
Assoc. Prof. Dr. Mukesh Kumar Maheshwari	HoD(EE)	Member
Assoc. Prof. Dr. Salma Hamza	HoD(E&ES)	Member
Assoc. Prof. Dr. Syed Safdar Ali	HoD(CS)	Member
Snr. Assoc. Prof. Dr. Sohaib Ahmad	Associate Dean	Member
Snr. Asst. Prof. Dr. Shoaib Mughal	HoD(CE)	Member
Snr. Assoc. Prof. Dr. Osama Rehman	HoD(SE)	Member
BULC		
Snr. Asst. Prof. Dr. Khawaja Qasim Maqbool	HOD(CS)	Member

Proceedings

Preliminaries

FBoS-ES meeting took place on 9th June 2023, with the quorum complete, the proceedings commenced at 1430 hrs, with recitation from the Holy Quran.

In his opening remarks, the Chair stressed the importance for participation in the proceedings while staying focused on the point under deliberation.

New Items:

Item2901: New Programme Proposal: Bachelor of Science in Robotics & Intelligent Systems (BS RIS)
Sponsor: HoD (EE) BUKC Referral Authority: DBoS EE BUKC

Summary of the Case

- The BS-RIS program curriculum have been designed with courses in robotics, IoT, artificial intelligence and machine learning which blends the curriculum to integrate new technologies of Industry 4.0
- The curriculum of BS RIS program includes the course work in robot modelling and control of industrial based manipulators, controlling of mobile robots as well as introduce the programming skills necessary to work with robots in different fields.
- This will a non-accredited programme of 4 years duration. Also, it will be a morning program with bi-annual intake.

Discussion

- The sponsor presented the agenda point. The house had a detailed discussion about the sensibility of program, student's intake, cost analysis etc. The house also discussed the curriculum of programme in details. The house recommends the updated program proposal attached at appendage 2901.

Decision 2901
The case to be forwarded for the approval in ACM.

Item 2902: New Programme Proposal: BS (Power & Energy)
Sponsor: HOD (EE) BUKC Referral Authority: DBOS EE BUKC

Summary of the Case

- Power and Energy System is an exciting and unique undergraduate program which is being offered to meet current energy crises. This BS 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 conventional energy generation methods with the addition of courses focused on sustainable renewable energy 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 associated processes
- Following are the salient features of the proposed program:
    - Students lower than 60% marks in HSSC can be enrolled.
    - No involvement of PEC in the program: intake restriction, yearly re-accreditation process fees, continues investment on the infrastructure and lab equipment.
    - Program will be approved by HEC, and established HEI can start any BS program with ease.
    - No program specific funds required for infrastructure and lab development.
    - Lower fees compare to BEE with almost equal opportunity and job prospects will attract more students. Student will be able to work in the field of electrical and electronics domain.
    - No restriction of the intake for DAE Students and they will be able to purse higher studies.
    - Could be beneficial for on job student since offered in evening.
    - More technical/field-oriented subjects.

Discussion
The sponsor presented the agenda point, after detailed discussion and deliberation the house suggested the proposed changes are attached as appendage 2902.

Decision 2902
The case to be forwarded for the approval in ACM.

Item 2903: Cluster Head Appointment Criteria	
Sponsor: HoD (CS) BUIC	Referral Authority: DBOS CS BUIC

Summary of the Case

The Department of Computer Science, BUIC offers BS(CS) and BS(IT) programs in which 825 and 636 students are enrolled respectively. The current ACM approved criteria of course waivers for Cluster Heads are that if more than 75 courses are included in a cluster, then two courses can be waived off (Ref MoM ACM Appendage 4038). Following this criterion means that only two courses per annum will be taught by the Cluster Heads of the programs. However, the NCEAC rule says that a FM will be counted only if he has taught 3 courses per anum in the program (NCEAC Evaluation Handbook 2021).

Currently, both in BS(CS) and BS(IT) programs there are more than 75 courses offered. Therefore, the Cluster Heads teach only two courses per annum and do not to fulfill the criteria to be counted.

Discussion:

The sponsor presented the agenda item, which was deliberated by the house in detail. During the discussion, the house recommended that two Cluster Heads should be appointed having one course waiver each. They can evenly divide the load among them for smooth implementation of semester. This way, they will be able to fulfill the requirement of NCEAC and be counted as FMs in their respective programs

Decision 2903:

The case to be forwarded for the approval in ACM.

Closing of the Meeting

There being no further points, the Chair brought the meeting to close, thanking the participants for their wholehearted participation in both sessions.

Prof. Dr Atif Raza Jafri
Dean (ES), Head FBoS
June, 2023

Distribution:

	Rector, Pro-Rector, Registrar
BUHQ:	DAA
BUIC:	DG BUIC, DIC HOD(EES), HOD(EE), HOD(CS), HOD(SE), HOD(CE)
BUKC:	DG BUKC, DKC HOD(EES), HOD(EE), HOD(CS), HOD(SE), HOD(CE)
BULC:	DLC, HOD(CS)

Appendages:

Appendage 2901

A. ACADEMIC DETAILS	
1	**Faculty/Department:** Faculty of Engineering and Sciences, Bahria University Karachi, Electrical Engineering Department
2	**Name of the Program:** Bachelor of Science in Robotics & Intelligent Systems – BS RIS
3	**Mission of the Program:** To produce robotics and intelligent system graduates with contemporary interdisciplinary approach keeping pace with changing technologies.
4	**Objectives of the Program:** • To provide essential understanding and demonstration capabilities which relates to the fundamental concepts of robotics and intelligent systems. • To create technically sound robotic workforce trained on modern robotic tools capable of handling and operation of robotic systems in diverse range of (national/international) industries. • To provide entrepreneurs who can lead the team and play role in defining how intelligent robotic systems will impact societies in future. • To prepare graduates pursuing advanced robotic studies and work in research related projects.
5	**Outcomes of the Program:** Graduates possess essential knowledge for meeting the requirements of industry and other organizations needing robotics and intelligent system professionals.
6	**Rationale for the Program:** The BS-RIS program curriculum have been designed with courses in robotics, IoT, artificial intelligence and machine learning which blends the curriculum to integrate new technologiesof Industry 4.0.
7	**Brief Description of the Program:** The curriculum of BS RIS program includes the course work in robot modelling and control of industrial based manipulators, controlling of mobile robots as well as introduce the programming skills necessary to work with robots in different fields.
8	**Duration:** 4 years
9	**Venue(s): On Site/Off Site/Both On & Off Site** *(Tick one; if Off Site, give details)* Engineering Block, Bahria University, 13 National Stadium Road, Karachi
10	**Programme Scheduling Format:** Morning (Bi-Annual)

11	**Proposed Date of Commencement:** Fall 2023
12	**Mode of Study/Examination:** Mode of study of BS Robotics and Intelligent Systems is based on classroom teaching. Assignments, quizzes, mid-term and final term exams will be used to evaluate the students in each semester. Students will be required to undertake 6 credit hours of Final Year Project.

13 **Additional Faculty Member(s) Required:** For intake of two batches per annum 8 faculty members (2 PhD and 6 MS) are required for the BS RIS program.

Following faculty member are already available, whereas, rest of the HR will be inducted as per schedule mentioned in section B7.

- Dr. Abdul Attayyab Khan, Ph.D.
- Dr. Taimoor Zafar

Research Interests: Robotics, Tactile Sensing, Machine Learning

Total 8 FMs (2 PhD and 6 MS) are required after program maturity may be required.

Year	No. of FMs	PhD	MS
First Year	2	-	2
Second Year	2	-	2
Third Year	2	-	2
Fourth Year	-	-	-

14 **Additional Skilled-Worker(s) Required:** *(Indicate if there is a requirement for additional Skilled Staff, fulltime/part-time, along with their qualifications/skill sets.)*

Additional Skilled Staff	**Numbers**	**Full time/ Part time**	**Qualification**
Lab Engineer	1	Full time	MS

15 **Additional Classroom(s) required:** Total 4 class rooms will be required, with the following breakdown.

First Year: 1 Classrooms
Second Year: 2 Classrooms
Third Year: 3 Classrooms
Fourth Year: 4 Classrooms

One classroom can be borrowed from Electrical Engineering Department

16 **Additional Requirement for Laboratories:** The computer labs may be shared with CS and SE department.

The CE department has Robotics lab and it will be shared. Moreover, it may be expanded/upgraded during the 3rd year of the program, if necessary.

17	**Additional Requirement for Books, Subscriptions, Memberships to Online Research Sites/ Repositories:** 100 Book Title.
18	**Minimum Entry Level:** Minimum 50% marks in Intermediate (HSSC) Examination (Pre-Engg./Comp Science/ Pre- Medical/DAE (all relevant field)) or equivalent qualifications with Mathematics certified by IBCC. **Deficiency:** For Pre-Medical students, the following deficiency course of mathematics will be taughtduring the first year. • Fundamentals of Mathematics I GSC 103 (3 Credit Hours) • Fundamentals of Mathematics II GSC 104 (3 Credit Hours)
19	**Admission Criteria:** Matric/O-level : 10% Intermediate/A-level: 40% Entry Test Score: 50%
20	**Additional/Different Examination Requirement** *(Indicate if there will be any examination requirement, additional to or different from the BU Academic Rules or Examination Policy in vague).*
21	**Number of Admissions Expected for First Intake:** 20 admissions for first intake.
22	**Number of Admissions Planned/Expected for Subsequent Intakes:** 20 admissions per intake.
23	**Referred by:** Dean engineering sciences
24	**Complete Plan of Studies, inclusive of complete Roadmap:** Complete plan for BS Robotics and Intelligent Systems Program is attached with this document for reference (appendage-2901A)
25	**Course Outlines, Descriptions, Pre-Requisites & Readings (Compulsory & Recommended)** Course outlines for BS Robotics and Intelligent Systems are attached with this document for reference (appendage-2901B).
B. FINANCIAL DETAILS	
1	**Source of Funding: BU: Fully**
2	**Degree Duration:** 4 years **Annual or Semester System:** Semester
3	**Expected fee to be charged based on Cost & Benefits Analysis:**

	Students			Fee per student		Total Fee		
Semester	Fresh	Existing	Total	**Fresh	*Existing	Fresh	Existing	Total
Fall 2023	20	0	20	138,250	0	2,765,000	0	**2,765,000**
Spring 2024	20	20	40	138,250	81,250	2,765,000	1,625,000	**4,390,000**
Fall 2024	20	40	60	138,250	81,250	2,765,000	3,250,000	**6,015,000**
Spring 2025	20	60	80	138,250	81,250	2,765,000	4,875,000	**7,640,000**
Fall 2025	20	80	100	138,250	81,250	2,765,000	6,500,000	**9,265,000**
Spring 2026	20	100	120	138,250	81,250	2,765,000	8,125,000	**10,890,000**
Fall 2026	20	120	140	138,250	81,250	2,765,000	9,750,000	**12,515,000**
Spring 2027	20	140	160	138,250	81,250	2,765,000	1,1375,000	**14,140,000**

*5000 Rs per credit hour and 16.25 credit hours per semester (Total 130 credit hours)
**For first semester: 27K admission fee, 10K Misc. expenditures, and 20K refundable security fee shall beapplicable

4 **Expected Number of students for 1st & 2nd Intakes:** 40 students

5 **Expected Earning from first two Intakes (B5): Rs. 7,155,000.0**

	Students			Fee per student		Total Fee		
Semester	**Fresh**	**Existing**	**Total**	**Fresh**	**Existing**	**Fresh**	**Existing**	**Total**
Fall 2023	20	0	20	138,250	0	2,765,000	0	**2,765,000**
Spring 2024	20	20	40	138,250	81,250	2,765,000	1,625,000	**4,390,000**

6 **Expected Earnings for the Next Three Years (B6):**

	Students			Fee per student		Total Fee		
Semester	**Fresh**	**Existing**	**Total**	**Fresh**	**Existing**	**Fresh**	**Existing**	**Total**
Fall 2024	20	40	60	138,250	81,250	2,765,000	3,250,000	**6,015,000**
Spring 2025	20	60	80	138,250	81,250	2,765,000	4,875,000	**7,640,000**
Fall 2025	20	80	100	138,250	81,250	2,765,000	6,500,000	**9,265,000**
Spring 2026	20	100	120	138,250	81,250	2,765,000	8,125,000	**10,890,000**
Fall 2026	20	120	140	138,250	81,250	2,765,000	9,750,000	**12,515,000**
Spring 2027	20	140	160	138,250	81,250	2,765,000	1,1375,000	**14,140,000**

Total 3 years earnings: Rs. 60, 465,000/-
Total earnings per annum: Rs. 16,905,000/-

7 **Total Estimated Salaries of Additional Human Resources per annum (B7):**

	Posts	Qualifications		Per Semester Salary (6months)
Semester	**Regular FM**	**PhD**	**MS**	
Fall 2023	1	-	1	840,000.00
Spring 2024	3	-	3	1,920,000.00
Fall 2024	4	-	4	2,800,000.00
Spring 2025	5	-	5	3,760,000.00
Fall 2025	8	2	6	6,640,000.00
Spring 2026	8	2	6	7,320,000.00
Fall 2026	8	2	6	7,920,000.00
Spring 2027	8	2	6	8,560,000.00

	*PhD 220K per month; MS 100K per month and 2500 VFM Per hour **Year 1: Rs. 2,760,000.00** **Year 2: Rs. 6,560,000.00** **Year 3: Rs. 13,960,000.00** **Year 4: Rs. 16,480,000.00** **Total estimated salaries per annum of HR:** Rs. 9,940,000 (per annum)
8	**Cost of Additional Laboratory Equipment/Tools (B8):** The CE department has Robotics lab and it may be shared. Moreover, it may be expanded/upgraded during the 3rd year of the program. The approximate cost may be 5 million.
9	**Cost of Additional Classrooms (B9):** N/A
10	**Cost of Additional Books, Subscription & Memberships to on-line Sites/Repositories (B10):** Year 2: Rs. 100,000.00
11	**Off-Site rental Expenses and Cost of other Fixtures (B11):** N/A
12	**Miscellaneous Expenses required for Starting the Program (B12):** – Advertisement: Rs. 100,000. – Printing & Stationary: Rs. 50,000. – Admin Cost: – Zero Visit: – Total: Rs. 150,000
13	**Annual Recurring Expenditures in Subsequent Years (B13):** – Salaries: Rs. 9,9440,000 (per annum) – Rentals: Nil – Subscriptions/Memberships: Nil – Advertisements: Rs. 100,000. – Printing & Stationary: Rs. 50,000. – Admin Cost: – Accreditation Fee: – Total: Rs. 1,0090,000.
14	**Total Cost of the Program (B14):** [Add B(7) to B(12)] Rs. 1,1340,000.00 (Per Year)
15	**Net Cost of the Program (B15):** [Subtract B(1) from B(14)] Rs. 11,340,000.0 (Per year)
16	**Net Earnings in First Year (B16):** [Subtract B(15) from B(5)] Rs. 5,565,000.00

appendage-2901A

BS ROBOTICS & INTELLIGENT SYSTEMS (BS-RIS)
ROADMAP

Curriculum

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Campus:	**Karachi and Islamabad**
Department:	**Department of Electrical Engineering**
Program Title:	**BS**
Program Level:	**Bachelor**
Total Duration of Program:	**4 years**
Total Number of Semesters:	**8 semesters**
Total Number of Credit Hours:	**130**
Number of Credit Hours per Semester:	**15-18**

Areas	**Courses**	**Credit Hours**
Robotics and Intelligent Systems Core Courses	**20**	**69**
Robotics and Intelligent Systems Elective Courses	**4**	**14**
Computing Courses	**3**	**12**
Mathematics and Supporting courses	**5**	**15**
General Education Courses	**6**	**14**
Management Science Course	**1**	**3**
Social Science Course	**1**	**3**
Total	**40**	**130**

Semester-1:

S.No.	**Pre-Requisite**	**Course Code**	**Course Title**	**Credit Hours**	**Theory**	**Lab**
1	None	GSC 113	Applied Physics	3+1	3	1
2	None	GSC 110	Applied Calculus & Analytical Geometry	3+0	3	0
3	None	ISL 101/ HSS 116	Islamic Studies/ Ethics	2+0	2	0
4	None	ENG 100	English-I	2+0	2	0
5	None	GSC 115	Circuit Analysis	3+1	3	1
Total Credit Hours in Semester-1				15	13	2

Semester-2:

S.No.	Pre-Requisite	Course Code	Course Title	Credit Hours	Theory	Lab
1	GSC 110	GSC 210	Differential Equations	3+0	3	0
2	None	CSC 113	Computer Programming	3+1	3	1
3	None	CEN 120	Digital Logic Design	3+1	3	1
4	None	ENG 134	Communication Skills	2+0	2	0
5	None	EEL 113	Engineering Workshop	0+1	0	1
6	None	EEL 121	Engineering Drawing & CAD	0+1	0	1
Total Credit Hours in Semester-2				15	11	4

Semester-3:

S.No.	Pre-Requisite	Course Code	Course Title	Credit Hours	Theory	Lab
1	GSC 110	GSC 220	Complex Variable & Transforms	3+0	3	0
2	CSC 113	CSC 210	Object Oriented Programming	3+1	3	1
3	GSC 115	EEN 224	Electronic Devices and Circuits	3+1	3	1
4	None	PAK 101	Pakistan Studies	2+0	2	0
5	None	MSC 231	Engineering Mechanics	3+0	3	0
Total Credit Hours in Semester-3				16	14	2

Semester-4:

S.No.	Pre-Requisite	Course Code	Course Title	Credit Hours	Theory	Lab

1	None	RIS 231	Introduction to Robotics	3+1	3	1
2	CSC 210	CSC 221	Data Structures & Algorithm	3+1	3	1
3	None	AIC 301	Machine Learning	2+1	2	1
4	None	EEN 313	Signal & Systems	3+1	3	1
5	None	GSC 121	Linear Algebra	3+0	3	0
Total Credit Hours in Semester-4				18	14	4

Semester-5:

S.No.	Pre-Requisite	Course Code	Course Title	Credit Hours	Theory	Lab
1	CEN 120	CEN 440	Embedded Systems Design	3+1	3	1
2	None	GSC 122	Probability and Statistics	3+0	3	0
3	XXXX	XXXX	Social Sciences Elective-I	3+0	3	0
4	EEN 313	EEN 412	Linear Control System	3+1	3	1
5	None	RIS 241	Sensors & Actuators	3+1	3	1
Total Credit Hours in Semester-5				18	15	3

Semester-6:

S.No.	Pre-Requisite	Course Code	Course Title	Credit Hours	Theory	Lab
1	None	ENG 321	Technical Writing	2+0	2	0
2	EEN 313	CEN 444	Digital Image Processing	3+1	3	1
3	CSC 210	RIS 361	Robotic System & Programing	3+1	3	1
4	CSC 210	AIC 201	Artificial Intelligence	3+1	3	1
5	XXX	XXX	RIS Elective I	3+0	3	0
Total Credit Hours in Semester-6				17	14	3

Semester-7:

S.No.	Pre-Requisite	Course Code	Course Title	Credit Hours	Theory	Lab
1	EEN 412	RIS 362	Robot Modelling & Control	3+1	3	1
2	XXX	XXX	RIS Elective II	3+1	3	1
3	AIC 301	RIS 474	Introduction to Deep Learning	3+1	3	1
4	None	XXXX	Project -I	0+3	0	3
Total Credit Hours in Semester-7				15	9	6

Semester-8:

S.No.	Pre-Requisite	Course Code	Course Title	Credit Hours	Theory	Lab
1	XXXX	XXXX	RIS Elective III	3+0	3	0
2	CSC 112	RIS 363	Internet of things (IoT)	3+0	3	0
3	None	XXXX	Management Elective-I	3+0	3	0
4	XXXX	XXXX	RIS Elective IV	3+1	3	1
5	None	XXXX	Project-II	0+3	0	3
Total Credit Hours in Semester-8				16	12	4

Total Credit Hours: 130

List of Courses

Computing Courses (12 credit hours)

Sr. No	Pre-req	Course Code	Course Title	Theory	Lab	CR
1	None	CSC 113	Computer Programming	3	1	4
2	CSC 113	CSC 210	Object Oriented Programming	3	1	4
3	CSC 210	CSC 221	Data Structures & Algorithm	3	1	4

Mathematics and Supporting courses (15 credit hours)

Sr. No	Pre-req	Course Code	Course Title	Theory	Lab	CR
1	None	GSC 110	Applied Calculus& Analytical Geometry	3	0	3
2	GSC 110	GSC 210	Differential Equations	3	0	3

3	GSC 110	GSC 220	Complex Variable & Transform	3	0	3
4	None	GSC 121	Linear Algebra	3	0	3
5	None	GSC 122	Probability and Statistics	3	0	3

General Education Courses (14 credit hours)

Pre-req	Course Code	Course Title	Theory	Lab	CR
None	GSC 113	Applied Physics	3	1	4
None	ISL 101/ HSS 116	Islamic Studies/ Ethics	2	0	2
None	ENG 100	English-I	2	0	2
None	ENG 134	Communication Skills	2	0	2
None	PAK 101	Pakistan Studies	2	0	2
None	ENG 321	Technical Writing	2	0	2

Robotics and Intelligent Systems Core Courses (69 credit hours)

Sr. No	Pre-req	Course Code	Course Title	Theory	Lab	CR
1	None	GSC 115	Circuit Analysis	3	1	4
2	None	CE 120	Digital Logic Design	3	1	4
3	None	EEL 113	Engineering Workshop	0	1	1
4	None	EEL 121	Engineering Drawing & CAD	0	1	1
5	GSC 115	EEN 224	Electronic Devices and Circuits	3	1	4
6	None	MSC 231	Engineering Mechanics	3	0	3
7	CEN 120	CEN 440	Embedded Systems Design	3	1	4
8	None	AIC 301	Machine Learning	2	1	3
9	None	EEN 313	Signal & Systems	3	1	4
10	None	RIS 231	Introduction to Robotics	3	1	4
11	EEN 313	EEN 412	Linear Control System	3	1	4
12	None	RIS 241	Sensors & Actuators	3	1	4
13	EEN 313	CEN 444	Digital Image Processing	3	1	4
14	CSC 210	RIS 361	Robotic System & Programing	3	1	4
15	CSC 210	AIC 201	Artificial Intelligence	3	1	4
16	EEN 412	RIS 362	Robot Modeling & Control	3	1	4
17	AIC 301	RIS 474	Introduction to Deep Learning	3	1	4

18	CSC 112	RIS 363	Internet of things (IoT)	3	0	3
19	None	XXXX	Project -I	0	3	3
20	None	XXXX	Project -II	0	3	3

Social Science Course (3 credit hours)

Sr. No	Pre-req	Course Code	Course Title	Theory	Lab	CR
1	None	HSS 422	Engineering Ethics	3	0	3
2	None	HSS 202	Introduction to Sociology	3	0	3
3	None	BES 103	Critical Thinking	3	0	3
4	None	HSS 456	Organizational Behavior	3	0	3
5	None	HSS 111	Introduction to International Relations	3	0	3

Management Science Course (3 credit hours)

Sr. No	Pre-req	Course Code	Course Title	Theory	Lab	CR
1	None	MGT 206	Entrepreneurship	3	0	3
2	None	MGT 652	Leadership	3	0	3
3	None	MGT 111	Principles of Management	3	0	3
4	None	HSS 411	Engineering Economics & Management	3	0	3
5	None	MGT 425	Project Management in Engineering	3	0	3

Robotics & Intelligent Systems Elective Courses

Sr. No	Pre-req	Course Code	Course Title	Theory	Lab	CR
1	RIS 231	RIS 481	Machine Vision & Robotics	3	3	3
2	RIS 241	RIS 482	Introduction to Haptics	3	3	3
3	RIS 362	RIS 483	Introduction to Humanoid Robots	3	3	3
4	RIS 362	RIS 484	Advanced Modelling of Robotics	3	3	3
5	GSC 121	RIS 485	Optimal Kinematic Design of Robots	3	3	3
6	RIS 361	RIS 486	Distributive Robotics/Swarm Robotics	3	3	3
7	RIS 477	CSC 410	Introduction to Cloud Computing	3	3	3
8	MSC 241	RIS 489	Mechanics of Materials	3	3	3
9	RIS 231	RIS 486	Swarm Robotics	3	3	3
10	None	RIS 471	Robot Process Automation	3	1	4
11	None	RIS 473	Introduction to R Programming	3	1	4
12	CEN 444	CSC 464	Computer Vision	3	1	4
13	RIS 477	RIS 475	Human Robot Interaction	3	1	4

14	RIS 477	RIS 476	Artificial Neural Network	3	1	4
15	RIS 477	RIS 487	AI for Computer Games	3	1	4
16	CSC 419	RIS 488	Chatbots	3	1	4

Appendage - 2901B

Course Outlines for Newly Added Courses

Course Title: Introduction to Robotics

Course Code: RIS 231

Credit Hours: (3+1)

Pre-Requisite: None

Objectives: This course is an overview of robotic and automated systems technology. The student will be introduced to basic manufacturing techniques, robot terminology, and different types of automation, safety, basic robotic programming, interfacing robotic communications, automated work cells, and robotic applications. Robot operations and programming fundamentals will be applied by the students.

Contents: Major components of robotic systems, degree of freedom, work envelope, tool centerpoint, classification of robotics system, arm geometry of robotic system

Recommended Book(s):

Introduction to Robotics — Colin D. Simpson

Reference Book(s):

Fundamentals of Robotics Engineering — Harry H. Poole

Course Title: Robot Modelling & Control

Course Code: RIS 362

Credit Hours: (3+1)

Pre-Requisite: Feedback Control Systems

Objectives: The objectives of the course are to provide an introductory understanding of robotics. Emphasis on basic of manipulators, coordinate transformation and kinematics, trajectory planning, control techniques, robot kinematics and dynamics in a closed loop system.

Contents: Rigid motions and Homogeneous transformation, forward & inverse kinematics, velocity kinematics, trajectory planning.

Recommended Book(s):

Robot Modelling and Control — Mark W. Spong

Reference Book(s):

Introduction to Robotics Mechanics and Control — John J. Craig

Course Title: Robot System & Programming

Course Code: RIS 361

Credit Hours: (3+1)

Pre-Requisite: Object Oriented Programming

Objectives: This course gives the introduction to ROS, focusing on the basic concepts fundamentalto use ROS from a user perspective. Three basic concepts are introduced: Nodes, Topics, and Services. Then, the specification of message types is covered. It also discuss the operationalizationof these concepts, covering the creation and management of packages, the programming of nodes that subscribe/publish to nodes and that call/serve services, and some useful command line tools. The course briefly discuss some graphical tools.

Contents: Packages, nodes, topics, services

Recommended Book(s):

Robot Operating System (ROS) for Beginners — Lentin Jospeh

Reference Book(s):

Robot Operating System (ROS) — Doubaa Anis

Course Title: Swarm Robotics

Course Code: RIS 486

Credit Hours: (3+0)

Pre-Requisite: Introduction to Robotics

Objectives: This course is an introduction to Swarm Robotics, which is the application of methods from swarm intelligence to robotics. It goes on to present methods that allow to understand how to design large-scale robot systems by going through many example scenarios on topics such as aggregation, coordinated motion (flocking), task allocation, self-assembly, collective construction, andenvironmental monitoring. The course also explains the methodology behind building multiple, simplerobots and how the complexity emerges from the multiple interactions between these robots such that they are able to solve difficult tasks.

Contents: Initial approach to Swarm Robotics, Swarm performance, Self-organization, Homogeneous and Heterogeneous Swarms

Recommended Book(s):

Swarm Robotics: A formal approach — Heiko Hamann **Reference**

Book(s): Evolutionary Swarm Robotics — Vito Trianni

Course Title: Advanced Modelling of Robotics

Course Code: RIS 484

Credit Hours: (3+0)

Pre-Requisite: Robot Modelling and Control

Objectives: The course formerly generalizes the modelling technique(Geometric, Kinematic and Dynamic) to robotic structures more complex than simpler cascade ones (e.g. branched, open/close and parallel connections) with extension to cases of presence of flexible links. Then it will be shown how the developed method can be used for calibration, simulation, kinematic/dynamic/interaction control, parametric identification and adaptive control of such more general robotic structures.

Contents: Geometric and kinematic modelling, constraint equations, fundamentals of screw theoryand its application to modelling

Recommended Book(s):

Modelling and Control of Manipulators — Wisama Khalil

Course Title: Introduction to Haptics

Course Code: RIS 482

Credit Hours: (3+0)

Pre-Requisite: Sensors and Actuators

Objectives: The objectives of the class is for students to learn how to design systems that enable force and tactile feedback of virtual environments. The students will learn how humans perceive realobjects to learn the salient properties that are necessary to be recreated in virtual environments. Dueto fast update rates necessary for these systems.

Contents: Application of haptic systems, haptics as an interaction modality, development of hapticsystems.

Recommended Book(s):

Engineering Haptic Devices — Christian Hatzfeld

Reference Book(s):

Making Sense of Haptics — Femke Elise van Beek

Course Title: Machine Vision & Robotics

Course Code: RIS 481

Credit Hours: 3+1

Pre-Requisite: Introduction to Robotics

Objectives: The aim of the course is to provide the students with the understanding of the basicprinciples underlying the design, analysis, and synthesis of robotic systems and machine vision technology in automation. This course will lay down the foundations of the engineering principles in such a way that the students can identify the appropriate concepts required in givenengineering problems and apply them to formulate the suitable engineering solutions in automation and other applications.

Contents: Applications of robotics and vision, Robot control, Image formation, transduction andsimple processing, Active vision and attention, Sensors for self-monitoring, General approaches and architectures

Recommended Book(s):

Keter Corke, Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer,2011.

Reference Book(s):

Rafael C. Gonzalez, and Richard E. Woods: Digital Image Processing, Prentice Hall, 2nd Edition,2001.

K. S. Fu, R. C. Gonzalez, and C. S. G. Lee, Robotics - Control, Sensing, Vision, and Intelligence,McGraw-Hill Book Company, 1987.

Course Title: Introduction to R Programming

Course Code: RIS 473

Credit Hours: (3+1) **Pre-**

Requisite: None

Objectives:

In this course students will learn how to program in R and how to use R for effective data analysis.You will learn how to install and configure software necessary for a statistical programming environment, discuss generic programming language concepts as they are implemented in a high-level statistical language. The course covers practical issues in statistical computing which includes programming in R, reading data into R, accessing R packages, writing R functions, debugging, and organizing and commenting R code. Topics in statistical data analysis and optimization will provide working examples.

Contents:

R Statistical Programming Language, RStudio Integrated Development Environment (IDE), Data importation methods, Basic R Data Types, Data processing and manipulation techniques,External add-in packages for R, Summary statistic functions, Data visualizations using ggplot, Error types.

Recommended Book(s):

The art of R programming - a tour of statistical software design, norman matloff

Reference Book(s):

Data Visualization Using R, Rahlf & Thomas, Springer

Course Title: AI for Computer Games

Course Code: RIS 487

Credit Hours: (3+1)

Pre-Requisite: Introduction to AI

Objectives:

This course equips students for a career in the rapidly growing game industry. Students will gainknowledge and skills in AI techniques that also apply to other domains, such as business planningand engineering. The primary focus of this course is on the use of AI techniques for generating efficient, intelligent behavior in games. Additional attention is given to AI algorithms for improving game play experience. The programming language used in the course is Java.

Contents:

Introduction to Game AI, Movement Algorithms and Steering Behavior, Coordinated Movement and Motor Control, Path finding, Decision-Making and Uncertainty, Introduction to LearningMechanisms, Random Number Generation and Minimaxing.

Recommended Book(s):

AI for games (3rd ed.). Taylor & Francis, Millington, I.

Reference Book(s):

Artificial Intelligence and Games, **Yannakakis,** Georgios N., **Togelius**, Julian, Springer

Course Title: Computer Vision

Course Code: CSC 464 **Credit**

Hours: (3+1)

Pre-Requisite: Digital Image Processing

Objectives:

This course provides an introduction to computer vision, including fundamentals of image formation, camera imaging geometry, feature detection and matching, stereo, motion estimation and tracking, image classification, scene understanding, and deep learning with neural networks. The basic methods for applications that include finding known models in images, depth recovery from stereo, camera calibration, image stabilization, automated alignment, tracking, boundary detection, and recognition.

Contents:

Image formation, projective geometry, lighting, Practical linear algebra, Image processing, descriptors, Image warping, linear models & optimization, Neural networks, Motion and flow, Single view geometry, Multi-view geometry.

Recommended Book(s):

Concise Computer Vision by Reinhard Klette

Computer Vision: Algorithms and Applications by Richard Szeliski.

Reference Book(s):

Deep Learning, by Goodfellow, Bengio, and Courville.

Course Title: Introduction to Deep Learning

Course Code: RIS 474

Credit Hours: (3+1)

Pre-Requisite: Introduction to AI

Objectives:

Deep Learning is a hierarchical learning methodology based on artificial neural networks which are algorithms inspired by the structure and function of the brain. It has applications in wide-rangeof industries these days such as face-recognizers working at massive scales, robotics, speech translation, text analysis, improving customer experience, autonomous vehicles etc. In this coursewe will take a "hands-on approach" and start will implementation of basic building blocks such astraining a simple perceptron and move to design and train a deep convolution neural network. Course will concentrate in developing both mathematical knowledge and implementation capabilities. The implementations will be python based using TensorFlow and Keras. After establishing our foundation in convolutional neural networks we will start looking into applicationsof deep learning in both spatial as well as time-series data and explore various networkarchitectures suited for each. The objective is to help you build a career in AI and Machine learning, to make you comfortable enough that you can understand various learning problems and develop your own deep learning based solutions.

Contents:

Neural Networks, ConvNet, Object Detection, Auto encoders, GANS, Sequence Models, MemoryAugmented NN, Deep Reinforcement Learning.

Recommended Book(s):

Neural Networks and Deep Learning by Charu C. Aggarwal

Reference Book(s):

Deep Learning (Adaptive Computation and Machine Learning series) Illustrated Edition by IanGoodfellow

Course Title: Robot Process Automation
Course Code: RIS 471
Credit Hours: (3+1)
Pre-Requisite: None

Objectives:

Robotic Process Automation (RPA) involves the development of software robots that can be programmed to do basic tasks across applications just as human workers do and has the potential to reduce the burden of repetitive, simple tasks on employees. This course outlines what RPA is
– and what it is not. Further, it explores how best to select opportunities to apply RPA, calculatingthe ROI on RPA projects, implementation best practices and pitfalls to avoid. Student will acquire an understanding of the principal aspects of Robotics Process Automation and learn how to implement RPA across the organization.

Contents:

RPA and Agile and CEM, Project Selection, Customer Journey Mapping, Agile, The central role of BPM, RPA and AI,

Recommended Book(s):

The Robotic Process Automation Handbook: A Guide to Implementing RPA Systems by Tom Taulli

Reference Book(s):

Robotic Process Automation: Guide to Building Software Robots, Automate Repetitive Tasks andBecome an RPA Consultant by Richard Murdoch

Course Title: Human Robot Interaction

Course Code: RIS 475

Credit Hours: (3+1)

Pre-Requisite: Introduction to AI

Objectives:

Human-robot interaction (HRI) is the field of study to understand, design and evaluate robotics systems for use by or with humans. This course brings together knowledge from robotics, artificialintelligence, language processing, image analysis, cognitive psychology, and other fields to enable robots to have more natural and more efficient interactions with humans.

Contents: Introduction, a short history of robotics, Study methods and designs for evaluating Human-Robot interaction, Interaction with intelligent autonomous systems, Physical interaction and haptics, Verbal and non-verbal communication, Affective Design, Acceptance and Trust, Empathic Human-Robot interaction, Developing long-term relationships, Applications: Domestic assistance /Eldercare, Ethical considerations.

Recommended Book(s):

Human-Robot Interaction: An Introduction 1st Edition by Christoph Bartneck, Tony BelpaemeFriederike Eyssel .

Reference Book(s):

New Frontiers in Human-Robot Interaction, Edited by Kerstin Dautenhahn and Joe SaundersISBN-10: 9027204551, ISBN-13: 978-9027204554

Context Aware Human-Robot and Human-Agent, Edited by Nadia M-Thalmann, Junsong Yuan,Daniel Thalmann, Bum-Jae You ISBN-10: 3319199463, ISBN-13: 978-3319199467

Course Title: Introduction to Cloud Computing

Course Code: CSC 410

Credit Hours: (3+0)

Pre-Requisite: Introduction to Machine Learning

Objectives:

The course presents a top-down view of cloud computing, from applications and administration to programming and infrastructure. Its main focus is on parallel programming techniques for cloudcomputing and large scale distributed systems which form the cloud infrastructure. The topics include: overview of cloud computing, cloud systems, parallel processing in the cloud, distributedstorage systems, virtualization, security in the cloud, and multicore operating systems.

Contents: Introduction to Cloud Computing, Cloud Computing Platforms, Parallel Programmingin the Cloud, Distributed Storage Systems, Virtualization, Cloud Security, Multicore Operating Systems

Recommended Book(s):

Cloud Computing by Lizhe Wang, Rajiv Ranjan, Jinjun Chen, Boualem Benatallah

Reference Book(s):

The Cloud Computing Book : The Future of Computing Explained by Douglas Comer

Course Title: Artificial Neural Network

Course Code: RIS 476

Credit Hours: (3+1)

Pre-Requisite: Introduction to Machine Learning

Objectives:

The course will give the comprehensive knowledge of the main provisions neuromathematics, main types of neural networks, students will be able to Know and apply the methods of trainingneural networks, Know the application of artificial neural networks, to be able to formalize the problem, to solve it by using a neural network.

Contents: Introduction to the course. History of artificial neural networks. Biological neural networks, Model of the formal neuron. Perceptron. Education perceptron, Kohonen network. Web counter proliferation, Associative Memory, Adaptive Resonance Theory, Genetic algorithms for learning neural networks.

Recommended Book(s):

Simon Haykin; Neural Networks: A Comprehensive Foundation; Prentice Hall; ISBN-13: 978-0131471399; 2008

Dan Simon; Evolutionary Optimization Algorithms; Wiley; ISBN-13: 978-0470937419; 2013

Reference Book(s):

Daniel Graupe; Principles of Artificial Neural Networks; World Scientific Publishing Company;ISBN-13: 978-9814522731; 2013

Course Title: Mechanics of Materials

Course Code: RIS 489

Credit Hours: (3+0)

Pre-Requisite: Engineering Mechanics

Objectives:

This course is the foundation to many advanced techniques that allow engineers to design machine components, mechanisms, predict failure and understand the physical properties of materials. Mechanics of Materials gives the student basic tools for stress, strain and deformation analysis. Methods for determining the stresses, strains and deformations produced by applied loads are presented. Engineering design concepts are integrated throughout the course.

Contents: Introduction to Stress Analysis, Introduction to Strain Analysis, Mechanical Propertiesof Solids (The Constitutive relations), Stress and strain analysis for axially loaded members, Stress & Strain analysis for member under torsional loading, Bending loads (beams)

Recommended Book(s):

Mechanics of Materials by Russell Hibbeler

Reference Book(s):

Mechanics of Materials by James M. Gere

Course Title: Machine Learning

Course Code: AIC 301

Credit Hours: (3+1)

Pre-Requisite: None

Objectives:

This course emphasizes learning algorithms and theory including concept, decision tree, neural network, computational, Bayesian, evolutionary, and reinforcement learning. Machine Learning isa key to develop intelligent systems and analyze data in science and engineering. Machine learning engines enable intelligent technologies such as Siri, Kinect or Google self-driving car, toname a few. At the same time machine learning methods help unlocking the information in our DNA and make sense of the flood of information gathered on the web, forming the basis of a newScience of Data. This course provides an introduction to the fundamental methods at the core ofmodern machine learning. It covers theoretical foundations as well as essential algorithms for supervised and unsupervised learning.

Contents:

Introduction to machine learning; concept learning: General-to-specific ordering of hypotheses, Version spaces Algorithm, Candidate elimination algorithm; Supervised Learning: decision trees,Naive Bayes, Artificial Neural Networks, Support Vector Machines, Overfitting, noisy data, and pruning, Measuring Classifier Accuracy; Linear and Logistic regression; Unsupervised Learning: Hierarchical Agglomerative Clustering. k-means partitional clustering; Self-Organizing Maps (SOM) k-Nearest-neighbor algorithm; Semi-supervised learning with EM using labeled and unlabeled data; Reinforcement Learning: Hidden Markov models, Monte Carlo inference Exploration vs. Exploitation Trade-off, Markov Decision Processes; Ensemble Learning: Using committees of multiple hypotheses, bagging, boosting.

Recommended Book(s):

Machine Learning: An Algorithmic Perspective (Second Edition) by Stephen Marsland, CRCPress, 2015.

Machine Learning, Tom, M., McGraw Hill, 1997.

Reference Book(s):

Machine Learning: A Probabilistic Perspective, Kevin P. Murphy, MIT Press, 2012

Course Title: Artificial Intelligence

Course Code: AIC 201

Credit Hours: (3+1)

Pre-Requisite: Object Oriented Programming

Objectives:

This course presents the principles of artificial intelligence (AI) through an exploration of its history, capabilities, technologies, framework, and its future. The AI applications in various industries with be reviewed through some case studies. Current trends in AI will be discussed andstudents will be encouraged to consider the potentials of AI to solve complex problems.

Contents:

An Introduction to Artificial Intelligence and its applications towards Knowledge Based Systems; Introduction to Reasoning and Knowledge Representation, Problem Solving by Searching (Informed searching, Uninformed searching, Heuristics, Local searching, Minmax algorithm, Alpha beta pruning); Case Studies: General Problem Solver, Eliza, Student, Macsyma; Learningfrom examples; Natural Language Processing; Recent trends in AI and applications of AI algorithms. Lisp & Prolog programming languages will be used to explore and illustrate various issues and techniques in Artificial Intelligence.

Recommended Book(s):

Russell, S. and Norvig, P. “Artificial Intelligence. A Modern Approach”, 3rd ed, Prentice Hall,Inc., 2015.

Reference Book(s):

Norvig, P., “Paradigms of Artificial Intelligence Programming: Case studies in Common Lisp”,Morgan Kaufman Publishers, Inc., 1992.

Luger, G.F. and Stubblefield, W.A., “AI algorithms, data structures, and idioms in Prolog, Lisp,and Java”, Pearson Addison-Wesley. 2009.

Course Title: Embedded Systems

Course Code: CEN 440

Credit Hours: (3+1)

Pre-Requisite: Digital Logic Design

Objectives:

This course will cover the basics of embedded system organization, system on programmable- chip technologies and real-time systems. It provides the advance

knowledge required for embedded computer design and development. Also to develop an understanding of various embedded systems which includes microcontrollers, raspberry pi processor and fieldprogrammable gate array.

Contents:

Introduction to Embedded Systems, Experience with Microcontrollers, Experience with Arduino, Architecture of AT-mega microcontroller, LCD interfacing with Arduino, DC motor speed and direction control with Arduino, ADC operation of Arduino, Hardware and software interrupts in Arduino, Experience with PIC microcontroller PIC parallel port programming, Timers in PIC microcontroller, ADC in PIC microcontroller, Interrupts in PIC microcontroller, Experience with Raspberry Pi processor, Python programming, Raspberry Pi architecture, GPIO interfacing of Raspberry Pi, PWM with Raspberry Pi.

Recommended Book(s):

PIC microcontroller and embedded systems by Mazidi, Majid Ali (Latest Edition)

Reference Book(s):

Learn Raspberry Pi Programming with Python by Donat, Wolfram (Latest Edition)

Course Title: Introduction to Humanoid Robots

Course Code: RIS 483

Credit Hours: (3+0)

Pre-Requisite: Robot Modelling and Control

Objectives:

This course provides an overview of the fundamentals and the recent research in the field of humanoid robotics. The course will cover kinematics and dynamics, postural stability, control, gait and trajectory generation and inertial parameter estimation. Additional advanced topics in learning, human-robot interaction and manipulation and grasping and human motion modeling will be covered as time permits.

Contents:

Develop kinematic and dynamic models for anthropomorphic body structures and simulate their forward and inverse kinematics and dynamics; Develop gaits and other trajectories for humanoidrobots; Implement controllers that ensure postural stability during trajectory execution for humanoid robots; Have a good overview of the current research in the field of humanoid robotics;Complete a graduate level research project in the field of humanoid robotics.

Recommended Book(s):

S. Kajita, H. Hirukawa, K. Harada and K. Yokoi, Introduction to Humanoid Robotics, Springer,2014.

Reference Book(s):

Dragomir Nenchev Atsushi Konno Teppei Tsujita, Humanoid Robotics Automation and Control

Course Title: Engineering Mechanics

Course Code: MSC 231

Credit Hours: (3+0)

Pre-Requisite: None

Objectives:

This course discusses the study of objects that are either at rest or moving with a constant velocity. Statics is important in the development of problem-solving skills. The course addressesto think about how forces and bodies act and react to one another. The student will learn how toanalyze word problems, pull out the important information and then solve. Some of the topics covered are pure kinematics (a mathematical description of motion only), while others are kinetic (determine motion in problems involving the concepts of force and energy). The course is restricted to 2-D (planar) mechanisms.

Contents:

Vector Operations, Coplanar Forces – Cartesian & Scalar Notation, 3d Vectors & Coordinate, Direction Angles, Transverse & Azimuth Angles, Position Vectors, Force Directed Along a Line, Dot Product, and Projection Along a Line. Structures: Difference between trusses, frames and beams, Assumptions followed in the analysis of structures, 2D truss, Method of joints, Method of section, Frame, Simple beam, types of loading and supports, Shear Force and bending, Moment diagram in beams, Relation, among, load, shear force and bending moment. Potential energy and equilibrium, stability, Center of Gravity and Moment of Inertia, First and second moment of area, Radius of Gyration, Kinematics of Particles, Kinetics of Particles, Dynamics of Rigid Bodies, Plane kinetics of rigid bodies, Introduction to 3D Dynamics

Recommended Book(s):

R. C. Hibbeler, Engineering Mechanics: Statics and Dynamics.

Reference Book(s):

Bedford, Fowler, Engineering Mechanics Statics.

Meriam, J. L., and Kraige, L. G., Engineering Mechanics, Dynamics, Sixth Edition (SI Version), John Wiley and SonsInc.,2008

Course Title: Sensors and Actuators

Course Code: RIS 241

Credit Hours: (3+1)

Pre-Requisite: None

Objectives:

This course discusses understanding basic laws and phenomena on which operation of sensors and actuators-transformation of energy is based. It equips students with fundamental knowledge and skills on sensors and actuator circuits and systems. Sensors are a key component in modern robotics, providing vital information for control processing. Along with sensors, conditioning circuits are also important to process the signal and convert it into a form suitable for the controllers. At the other end of the system, actuators are vital to provide the mechanical output required for many applications.

Contents:

Methods of sensing, signal processing, data analysis, decision making, control, and analysis. Introduction of applicable sensors and actuators in robotics.

- Sensor and actuator criteria for a robotic system.
- Sensor performance criteria and selection: thermocouples, resistive sensors, inductive

sensors, capacitive sensors, piezoelectric sensors, encoders and tachometers.

- Impact of sensor characteristics such as range, accuracy, precision, sensitivity, linearity, resolution, in robotic system.
- Actuator performance criteria and selection: fluidic actuators, solenoids and voice coil motors, stepper motors, DC motors, piezoelectric actuators, shape memory alloy, actuators.
- MEMS sensors and actuators. Transfer function models for commonly employed actuators analyze their impact on the robotic system.

Recommended Book(s):

N. Nise, "Control Systems Engineering", 7th Ed., Wiley, ISBN: 978-1-118-80063-8

Reference Book(s):

Robert H. Bishop, "Mechatronic Systems, Sensors, and Actuators: Fundamentals and Modeling," CRC Press, ISBN: 978-0-8493-9258-0

Required Software: MATLAB/Simulink, Onshape.

Course Title: Robotic system and programming

Course Code: RIS 361

Credit Hours: (3+1)

Pre-Requisite: Object Oriented Programming

Objectives:

This course will prepare students to design, build, and program a robot. The student will apply programming in Python to perform various robotic movements involving transformations, tracking, steering, and kinematics. It is designed to prepare students to implement the concepts of robotic programming using small robots. The course will teach students the basics of programming that will be used to implement algorithms. The student will learn basic digital design and the structure of circuits. The student will use a programming language to implement various tasks of sensors, actuators, manipulators, and gears. The basics of robot mechanics will be covered including power, torque, acceleration, velocity, and kinematics.

Contents:

Memory concepts, debugging, recursion, search, abstractions, threading, and message passing. MATLAB programs Programming in C/C++/Python. Familiarity with Linux the environment and its administration. Familiarity with software version control systems (e.g. Subversion, Mercurial, CMake, Git), ROS, linear algebra. Ubuntu 18.04 LTS or one of its variants such as Xubuntu, Kubuntu and ROS Melodic.

Recommended Book(s):

Programming Robots with ROS: A Practical Introduction to the Robot Operating System 1st Edition

Reference Book(s):

Practical Robotics in C++: Build and Program Real Autonomous Robots Using Raspberry Pi.

Course Title: Introduction to Deep Learning

Course Code: RIS 474

Credit Hours: (3+1)

Pre-Requisite: Machine Learning

Objectives:

Deep Learning (DL) can be considered an advanced type of Machine Learning technology, which can solve problems that cannot be always efficiently or effectively solved by traditional ML algorithms. Artificial Neural Networks (ANNs) are the building blocks of all DL algorithms. Some famous DL examples include image generation, object detection in images and videos, text generation, text summarization, face recognition, image captioning and enhanced time series forecasting models.

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Contents:

Brief introduction to Deep Learning (DL), Potential student projects, Differences from Machine Learning (ML), Evolution of ML and DL, Importance of Artificial Neural Networks (ANNs) Shallow ANNs, Single layer, Multi-layer, Perceptron Rule, Gradient Descent, Backpropagation, Loss Functions, Hyperparameter tuning, Deep ANNs and Regularization, Optimization Algorithms, Batch Normalization, Practical Aspects, DL Pipeline and Strategy, Convolutional Neural Networks, ConvNets, Edge Detection, Padding, Convolution Operator, CNN architecture, Parameter Sharing, Object Localization and Detection, Le-Net, AlexNet, VGG, Residual Networks, Inception Net, Recurrent Neural Networks (RNN), Sequence Modeling, Building the RNN, Backpropagation through time, LSTM, Attention Networks, Natural Language Processing, Word Embedding Applications, Generative Models – Restricted Boltzmann Machines and Deep Belief Networks, Generative Models Autoencoders, Variational, Stacked, Denoising, Generative Models – Generative Adversarial Networks, Miscellaneous Topics – Capsule Networks, Convolutional LSTM, One Shot Learning, Siamese Networks, Triplet Loss, Graph CNN.

Recommended Book(s):

Deep Learning with Python, by Francois Challet, Manning Publications

Reference Book(s):

- Introduction to Machine Learning by Ethem Alpadyn (latest edition)
- Machine Learning: A Probabilistic Perspective by Kevin P. Murphy

Course Title: Internet of Things

Course Code: RIS 363

Credit Hours: (3+0)

Pre-Requisite: Computer Programming

Objectives:

The Internet of Things (IoT) is the network of physical objects in which microprocessor and wireless radios are embedded to intelligently serve people in a collaborative manner. In future, IoT is expected to revolutionize many areas of human life i.e., agriculture, healthcare, transportation, manufacturing, engineering etc. This undergraduate course covers the conceptual understanding of IoT fundamentals.

Contents:

Introduction to IoT**,** IoT Application Domains**,** Smart Object Capabilities**,** IoT Enabling Technologies**,** IoT Architecture**,** Anatomy of IoT Devices**,** RFID Basics**,** Basics of Wireless Networking**,** Basics **o**f Wireless Sensor Networks**,** Introduction to Arduino Programming**,** Introduction of IoT with **R**aspberry Pi**,** MAC Layer of Wireless Networks**,** Routing Layer of Wireless Networks**,** IoT Protocol Stack**,** Application Layer Protocol**,** MQTT**,** Application Layer Protocol**,**

CoAP**,** Network Layer **P**rotocol**,** 6LoWPAN**,** Routing Protocol**,** RPL**,** Service Discovery Protocol**,** mDNS**,** Service Discovery Protocol**,** DNS-SD– Social IoTs**.**

Recommended Book(s):

J. Biron and J. Follett, "Foundational Elements of an IoT Solution", O'Reilly Media, 2016.

Reference Book(s):

• Keysight Technologies, The Internet of Things: Enabling Technologies and Solutions for Design and Testa, Application Note, 2016.

Course Title: Optimal Kinematic Design of Robot

Course Code: RIS 485

Credit Hours: (3+0)

Pre-Requisite: Linear Algebra

Objectives:

The course is aimed at developing skills on how to design and implement the capabilities of a robotic platform.

Contents:

Kinematics of Robot design. Mechanisms and kinematic of wheeled robots. Sensors used for the perception capabilities of the robot. Perception applied to allow the robot to understand the context of operation. Motion planning and control of the robot in complex contexts. Optimal planning (Dynamic Programming approach).

Recommended Book(s):

Modern Robotics: Mechanics, Planning, and Control by Kevin M. Lynch (Author), Frank C. Park.

Reference Book(s):

Robotics Everything You Need to Know About Robotics from Beginner to Expert by Peter Mckinnon.

Course Title: Electronic Devices and Circuits

Course Code: EEN 224

Credit Hours: (3+1)

Pre-Requisite: Linear Circuit Analysis

Objectives:

This course is intended to give the students an understanding to semiconductor materials, its basic structure, properties, carrier concentration, energy band gap, carrier transport in semiconductor. The design and applications of electronic devices and circuits such as passive components like diode and transistor. It will also provide the students an insight into characteristics, operation and design of various semiconductor devices and their applications in electronic circuits. Students will be able to do small and large signal AC Analysis, Transistor Biasing and High Frequency response of different amplifiers. This course introduces both bipolar and MOS analog integrated circuits. Operation of different types of Power Amplifiers and Oscillators will also be covered in this course.

Contents:

Semiconductor Theory, Diodes Circuits and Applications, Special Purpose Diodes, Bipolar Junction Transistors, Transistor Biasing Circuits, Amplifier Design and Loading effects, Field Effect Transistors, MOSFET Small Signal Analysis, Frequency Response of MOSFETs, BJT Small Signal Analysis, BJT Small Signal Analysis, Multi-Stage Amplifiers, Differential Amplifiers, Power Amplifiers, Current Mirror and Current Source Circuits, Oscillators.

Recommended Book(s):

- Adel S. Sedra & Kenneth C. Smith, "Microelectronic Circuits – Theory & Applications"

Reference Book(s):

1. Behzad Razavi, "Fundamentals of Microelectronics."
2. Norbert R. Malik, "Electronic Circuits – Analysis, Simulation & Design."
3. M. H. Rashid, "Microelectronic Circuits – Analysis & Design."
4. Robert Boylestad & Louis Nashelsky, "Electronic Devices and Circuit Theory"
5. Theodore F. Bogart, Jeffrey S. Beasley & Guillermo Rico, "Electronic Devices and Circuits"
6. Albert Malvino & David Bates, "Electronics Principles."

Course Title: Engineering Workshop

Course Code: EEL 113

Credit Hours: (0+1)

Pre-Requisite: None

Objectives:

Engineering Workshop deals with the basic skills of robotics and AI students. It introduces the basic electronic components, electrical wiring, soldering and PCB designing & fabrication using manual and automatic process. This course is designed for freshmen engineering and science students to provide them a basic introduction of various stages involved in an engineering product design. It will help students to interpret and create computer aided mechanical parts and assembly drawings, interpret and create schematic and layout drawings for electronic circuits, identify materials and select manufacturing processes for engineering products. Students will also be given an opportunity to get hands on experience on conventional and non-conventional methods for rapid prototyping.

Contents:

1. Introduction To Printed Circuit Boards, Its Manufacturing Methods & ISIS Proteus
2. Designing Schematics
3. Single Sided PCB Layout Designing
4. Double Sided PCB Layout Designing
5. Manual Routing and Copper Pouring
6. Pattern And Component Editing
7. Printed Circuit Board Fabrication
8. Introduction to Materials and Processes
9. Sizing, Cutting and Assembling of Robot Body
10. Joints and Links of Robot
11. Machining Process for Robots
12. Basic Motor Driver Circuits
13. Robot Building (Make Your First Robot)

Recommended Book(s):

- Lab Manual

Appendage 2902

NEW PROGRAMME PROPOSAL
BS Power and Renewable Energy

A. Academic Details	
1.	**Faculty/Institute/Department:** Faculty of Engineering and Sciences, Bahria University Karachi Campus, Electrical Engineering Department
2.	**Name of the Program:** BS (Power & Renewable Energy)
3.	**Mission of the Program:** To produce trained human resource in the discipline of Power and Renewable Energy Systems Engineering for exploiting energy resources to enhance economic growth of the country.
4.	**Objectives of the Program:** • 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 • Employed in the public or private sectors in the areas of energy science, energy engineering or energy business management.
5.	**Outcomes of the Program:** If the curriculum prescribed for the undergraduate students is implemented effectively, the Energy Systems Engineering graduates would: • Possess essential engineering knowledge for meeting the requirements of industries and other organizations needing graduate engineers. • Have the academic background and basic research skills to pursue graduate studies at national and international level. • Exploit renewable energy resources using hardware and software to solve the energy crises and to provide new solutions using innovative designs and techniques. • Function effectively in multi-disciplinary team for energy solutions. • Assist colleagues and co-workers in their professional development and support them in following the ethics.
6.	**Rationale for the Program:**

	• Following are the salient features of the proposed program: o Students lower than 60% marks in HSSC can be enrolled. o No involvement of PEC in the program: intake restriction, yearly re-accreditation process fees, continues investment on the infrastructure and lab equipment. o Program will be approved by HEC, and established HEI can start any BS program with ease. o No program specific funds required for infrastructure and lab development. o Lower fees compare to BEE with almost equal opportunity and job prospects will attract more students. Student will be able to work in the field of electrical and electronics domain. o No restriction of the intake for DAE Students and they will be able to purse higher studies. o Could be beneficial for on job student since offered in evening. o More technical/field-oriented subjects.
7.	**Brief Description of the Program:** Power and Renewable Energy System is an exciting and unique undergraduate program which is being offered to meet current energy crises. This BS 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 conventional energy generation methods with the addition of courses focused on sustainable renewable energy 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 associated processes.
8.	**Duration:** 04 Years
9.	**Venue (s):** NCMS Building, Bahria University, 13, National Stadium Road, Karachi.
10.	**Program Scheduling Format (Morning/Evening/Weekend) (Bi-Semester/Trimester):** Bi-annual (Evening)
11.	**Proposed Date of Commencement:** Fall 2023
12.	**Mode of Study/Examination:**

	Mode of study for BS (Power & Energy) is based on classroom teaching and labs. Assignments, quizzes, presentations, projects, mid-term exam and final term exams will be used to evaluate the students in each semester.
13.	**Additional Faculty Member(s) Required:** Power & Energy faculty is currently comprising of 15 members including 8 PhD and 7 MS. Details of these faculty members are as follows • Name: **Prof. Dr. Haroon Rasheed**, PhD (Electrical), AIT, Thailand. Research Interests: Smart Grid Systems, Renewable Energy Optimization, Network coding, Signal Processing, Ultra-Wide Band and Femto cell applications. • Name: **Dr. Anzar Alam, Senior Associate Professor**, PhD (Electrical), Mid Sweden University, Sweden Research Interests: Instrumentation & Control, Image & Video Processing, Power Electronics • Name: **Dr. Mukesh Kumar Maheshwari,** Senior Associate Professor, PhD (Electronics & Electrical), Sungkyunkwan University, South Korea Research Interest: Wireless Communication • Name: **Dr. Muhammad Raza, Associate Professor**, PhD (Power), Universitat Politècnica de Catalunya BarcelonaTech (UPC), Barcelona, Spain Research Interests: Offshore Wind Energy • Name: **Dr. Aurangzeb Rashid Masud, Senior Assistant Professor, PhD** (Electronics & Electrical), Sungkyunkwan University, South Korea Research Interests: Display devices and Materials. • Name: **Dr. Abdul Attayyab Khan, Senior Assistant Professor,** PhD (Advanced Robotics and Robot Design), University of Genova, Italy Research Interests: System Controls and Robotics, Robotic Vision, Tactile sensing in Robotics • Name: **Dr. Taimoor Zafar, Assistant Professor,** PhD (Electrical Engineering), Bahria University, Pakistan Research Interests: Integrated system health monitoring and prognostics, inverse problems, multisensory data fusion, Nondestructive testing, Reliability Analysis • Name: **Engr. Muhammad Khalid, Senior Assistant Professor**, MS (Electrical Engineering), NED University, Karachi Pakistan. Research Interests: Heterojunction and Multijunction Solar Cells. • Name: **Engr. Faraz Humayun, Senior** Assistant Professor, MS (Electrical Engineering), NED University, Karachi Pakistan. Research Interests: Electrical Power

	• Name: **Engr. Burhan Ahmed, Senior** Assistant Professor, MS (Electrical Engineering), NED University, Karachi Pakistan. Research Interests: Power Electronic, Electronic, Converters. • Name: **Engr. Faisal Siddiqui, Senior** Assistant Professor, MS (Electrical Engineering), Wayne State University, MI, USA. Research Interests: Integrated Circuits design for Wireless Application, Full Duplex Transceiver for 5G Communication. • Name: **Engr. Umair Shahid,** Assistant Professor, MS (Electronics & Telecommunication), Poznan University of Technology, Poland Research Interest: Wireless Communication and Digital Signal Processing • Name: **Engr. Muhammad Zuhair Arfeen,** Assistant Professor, MSc (Advanced Microelectronic Systems Engineering), University of Bristol, UK Research Interest: Embedded System • Name: **Engr. Basit Ali**, Lecturer, MS (Power Engineering), Bahria University, Islamabad, Pakistan. Research Interests: Electrical Power Research Interest: Power Electronics, Industrial Electronics
14.	**Additional Skilled-Worker(s) Required:** None
15.	**Availability/Requirement of Classrooms (Provide details, use extra sheet if required):** There is no mandatory requirement of classes for BS (Power & Energy) program. Classrooms available to the Electrical Department are sufficient to execute the program.
16.	**Availability/Requirement of Laboratories, (provide details, use extra sheet if required):** • Power Transmission and Distribution Lab • Power Generation and Protection/ High Voltage Lab • Electrical Machine Lab. • Applied Physics Lab • Workshop Lab • Analog Electronics and Devices Lab • Digital Logic Design Lab
17.	**If existing labs suffice, requirement for any additional equipment? (Provide details, use extra sheet if required):** Nil

18.	**Additional Requirement for Books, Subscriptions, Memberships to Online Research Sites/ Repositories:** At least 100 books, journals, and resources.
19.	**Minimum Entry Level:** As per BU policy, i.e., the candidates seeking admission in BS (Power & Energy) should have qualified the Intermediate examination from any Board of Intermediate and Secondary Education in Pakistan 'OR' An examination equivalent to the Intermediate for which such candidates must submit Equivalence Certificate issued by the Inter-Board Chairman Committee, Islamabad. Applicants must have scored minimum 50% marks in Pre-Engineering field OR Pre-Medical with additional Mathematics OR DAE in (Electrical, Electronics, Telecom; Biomedical; Computer)
19.	**Admission Criteria:** SSC, HSSC or Equivalent, Admission Test and Interview
20.	**Additional/Different Examination Requirement** (Indicate if there will be any examination requirement, additional to or different from the BU Academic Rules or Examination Policy in vogue). Nil
21.	**Number of Admissions Expected for First Intake:** 20 admissions for first intake
22.	**Number of Admissions Planned/ Expected for Subsequent Intake:** 20 admissions per intake
23.	**Complete Plan of Studies, inclusive of complete Roadmap:** Complete plan for BS (Power & Energy) Program is attached with this document for reference (**Appendage-2902A**).
24.	**Course Outlines, Descriptions, Pre-Requisites & Readings (Compulsory &Recommended)** Course outlines for BS (Power & Energy) Program are attached with this document for reference (**Appendage-2902B**).
25.	**Date of Approval by the Board of Study?**

B. FINANCIAL ANALYSIS

1.	**Source of Funding:** • BU: Fully/Partially: Fully • **Public Sector (B1): Fully/Partially** *(provide complete details; attach MOU, agreement etc.)* • **NNGO (B1): Fully/Partially** *(provide complete details; attach MOU, agreement etc.)* • **INGO (B1): Fully/Partially** *(provide complete details; attach MOU, agreement etc.)* • **UN/IGO (B1): Fully/Partially** *(provide complete details; attach MOU, agreement etc.)*
2.	**Degree Duration:** 4 years **Annual or Semester System: Semester**
3.	**Expected fee to be charged based on Cost & Benefits Analysis:**

	Students	Fee per student	Total Fee

Semester	Fresh	Existing	Total	Fresh	Existing	Fresh	Existing	Total
Fall 2023	20	0	20	138,250	0	2,765,000	0	**2,765,000**
Spring 2024	20	20	40	138,250	81,250	2,765,000	1625000	**4,390,000**
Fall 2024	20	40	60	138,250	81,250	2,765,000	3250000	**6,015,000**
Spring 2025	20	60	80	138,250	81,250	2,765,000	4875000	**7,640,000**
Fall 2025	20	80	100	138,250	81,250	2,765,000	6500000	**9,265,000**
Spring 2026	20	100	120	138,250	81,250	2,765,000	8125000	**10,890,000**
Fall 2026	20	120	140	138,250	81,250	2,765,000	9750000	**12,515,000**
Spring 2027	20	140	160	138,250	81,250	2,765,000	11375000	**14,140,000**

*5000 Rs per credit hour and 16.25 credit hours per semester (Total 130 credit hours)
**For first semester: 27K admission fee, 10K Misc. expenditures, and 20K refundable security fee shall be applicable

4. **Expected Number of students for 1st & 2nd Intakes:** 60 students

5. **Expected Earning from first two Intakes (B5):** Rs. 7,155,000/-

	Students			Fee per student		Total Fee		
Semester	**Fresh**	**Existing**	**Total**	**Fresh**	**Existing**	**Fresh**	**Existing**	**Total**
Fall 2023	20	0	20	138,250	0	2,765,000	0	**2,765,000**
Spring 2024	20	20	40	138,250	81,250	2,765,000	1625000	**4,390,000**

6. **Expected Earnings for the Next Three Years (B6):**

	Students			Fee per student		Total Fee		
Semester	**Fresh**	**Existing**	**Total**	**Fresh**	**Existing**	**Fresh**	**Existing**	**Total**
Fall 2024	20	40	60	138,250	81,250	2,765,000	3250000	**6,015,000**
Spring 2025	20	60	80	138,250	81,250	2,765,000	4875000	**7,640,000**
Fall 2025	20	80	100	138,250	81,250	2,765,000	6500000	**9,265,000**
Spring 2026	20	100	120	138,250	81,250	2,765,000	8125000	**10,890,000**
Fall 2026	20	120	140	138,250	81,250	2,765,000	9750000	**12,515,000**
Spring 2027	20	140	160	138,250	81,250	2,765,000	11375000	**14,140,000**

Total 3 years earnings: Rs. 60, 465,000/-
Total earnings per annum: Rs. 16,905,000/-

7. **Total Estimated Salaries of all Extra Human Resources per Annum:**

	Work load		Per Semester Salary (Rs. 2500 per hour)
Semester	**Course**	**Credit Hours**	**FM**
Fall 2023	5.00	15.00	600,000.00
Spring 2024	11.00	30.00	1,200,000.00
Fall 2024	16.00	46.00	1,840,000.00
Spring 2025	21.00	63.00	2,520,000.00
Fall 2025	26.00	80.00	3,200,000.00
Spring 2026	31.00	97.00	3,880,000.00
Fall 2026	36.00	114.00	4,560,000.00
Spring 2027	41.00	130.00	5,200,000.00

2500 VFM Per hour

1st Year: 1,800,000/-
2nd Year: 43,60,000/-
3rd Year: 7,080,000/-

	4th Year: 9,760,000/- **Total estimated salaries per annum of HR:** Rs. 5,750,000/= (per annum)
8	**Cost of <u>Additional</u> Laboratory Equipment/Tools (B8):** N/A
9	**Cost of Additional Classrooms (B9):** N/A
10	**Cost of Additional Books, Subscription & Memberships to on-line Sites/Repositories (B10):** Year 2: Rs. 100,000/-
11	**Off-Site rental Expenses and Cost of other Fixtures (B11):** N/A
12	**Miscellaneous Expenses required for Starting the Program (B12):** - Advertisement: Rs. 100,000/- - Printing & Stationery: Rs. 50,000/- - Admin Cost: Nil Outreach visit: Rs. 50,000/-Total: Rs. 200,000/-
13	**Annual Recurring Expenditures in Subsequent Years (B13):** - Rentals: Nil - Subscriptions/Memberships: Nil - Advertisements: Rs. 100,000 - Printing & Stationery: Rs. 50,000 - Admin Cost: Nil Outreach visit: Rs. 50,000Total: Rs. 2,00,000/-
14	**Total Cost of the Program (B14):** [Add B(7) to B(12)] 1st Year: 2,100,000/= 2nd Year: 4,660,000/= 3rd Year: 7,380,000/= 4th Year: 10,060,000/= **Total cost per year: Rs. 60,50,000/=**
15	**Net Cost of the Program (B15): [Subtract B(1) from B(14)] Rs. 60,50,000.00/-**
16	**Net Earnings in First Year (B16): [Subtract B(15) from B(5)] Rs. 1,105,000.00/-**

Appendage-2902A

BACHELOR OF SCIENCE (POWER & RENEWABLE ENERGY) ROADMAP

Curriculum

Campus:	**Karachi**
Department:	**Department of Electrical Engineering**
Program Title:	**BS**
Program Level:	**Bachelors**
Total Duration of Program:	**4 years**
Total Number of Semesters:	**8 semesters**
Total Number of Credit Hours:	**130**
Number of Credit Hours per Semester:	**15-18**

Areas	Courses	Credit Hours
Power & Renewable Energy Core Courses	**22**	**72**
Power & Renewable Energy Elective Courses	**5**	**18**
Computing Courses	**1**	**3**
Mathematics and Supporting courses	**4**	**12**
General Education Courses	**5**	**13**
Management Science Course	**4**	**10**
Social Science Course	**1**	**3**
Total	**42**	**131**

Semester-1

S.No.	Pre-Requisite	Course Code	Course Title	Credit Hours	Theory	Lab
1	None	GSC 113	Applied Physics	3+1	3	1
2	None	MAT 121	Applied Mathematics – I	3+0	3	0
3	None	ISL 101/HSS 116	Islamic Studies/Ethics	2+0	2	0
4	None	ENV 440	Energy and Environment	2+0	2	0
5	None	GSC 115	Circuit Analysis	3+1	3	1
Total Credit Hours in Semester-1				15	13	2

Semester-2

S.No	Pre-Requisite	Course Code	Course Title	Credit Hours	Theory	Lab
1	None	ESC 111	Basic Mechanical Engineering	2+0	2	0
2	MAT 121	MAT 122	Applied Mathematics - II	3+0	3	0
3	None	EEL 112	Workshop Practice	0+1	0	1
4	None	CSC 112	Programming Fundamentals	2+1	2	1
5	None	EEL 121	Engineering Drawing & CAD	0+1	0	1
6	None	CEN 120	Digital Logic Design	3+1	3	1

7	None	PAK 101	Pakistan Studies	2+0	2	0
Total Credit Hours in Semester-2				16	12	4

Semester-3

S.No.	Pre-Requisite	Course Code	Course Title	Credit Hours	Theory	Lab
1	GSC 115	EEN 312	Electrical Machine	3+1	3	1
2	GSC 115	EEN 224	Electronic Devices & Circuits	3+1	3	1
3	None	ENG 100	English-I	2+0	2	0
4	MAT 121	EEN 226	Probability Methods in Engineering	3+0	3	0
5	None	EEP 448	Renewable Energy Systems	3+0	3	0
Total Credit Hours in Semester-3				16	14	2

Semester-4

S.No.	Pre-Requisite	Course Code	Course Title	Credit Hours	Theory	Lab
1	EEN 224	EEP 468	Power Electronics	3+1	3	1
2	GSC 115	EEN 433	Powe Distribution and Utilization	3+1	3	1
3	MAT 122	GSC 320	Numerical Analysis	3+0	3	0
4	None	EPS-220	Energy Economics, Policy, and Managements	2+0	2	0
5	CEN 120	CEN 440	Embedded Systems Design	3+1	3	1
Total Credit Hours in Semester-4				17	14	3

Semester-5

S.No.	Pre-Requisite	Course Code	Course Title	Credit Hours	Theory	Lab
1	None	MGT 425	Project Management in Engineering	3+0	3	0
2	GSC 115	EEP 331	Power System Analysis	3+1	3	1
3	EEN 224	EEN 316	Instrumentation & Measurements	3+1	3	1
4	None	ENG 320	Technical Report Writing and Presentation Skills	3+0	3	0
5	None	xxxx	Social Science Elective-1	3+0	3	0
Total Credit Hours in Semester-5				17	15	2

Semester-6

S.No.	Pre-Requisite	Course Code	Course Title	Credit Hours	Theory	Lab
1	None	EPS-324	Energy Conservation and Auditing	3+0	3	0
2	None	EPS 345	Bio-Energy System	2+0	2	0
3	EEP 448	EPS 378	Integration of Distributed Power Generation	3+1	3	1
4	CEN 120	CEN-354	Programming for DSP/FPGA	3+1	3	1
5	XXXX	XXXX	Elective – I	3+1	3	1
Total Credit Hours in Semester-6				17	14	3

Semester-7

S.No.	Pre-Requisite	Course Code	Course Title	Credit Hours	Theory	Lab
1	--	FYP 400	Final Year Project	0+3	0	3
2	None	MGT 437	Total Quality Management	3+0	3	0
3	EEP 331	EEP 444	Power System Protection	3+1	3	1
4	XXXX	XXXX	Elective – II	3+1	3	1
5	XXXX	XXXX	Elective - III	3+0	3	0
Total Credit Hours in Semester-7				17	12	5

Semester-8

S.No.	Pre-Requisite	Course Code	Course Title	Credit Hours	Theory	Lab
1	--	FYP 400	Final Year Project	0+3	0	3
2	None	MKT 422	Business Planning in Energy System	2+0	2	0
3	EEN 312	EEP 475	FACTs and HVDC Transmission	3+1	3	1
4	XXXX	XXXX	Elective - IV	3+0	3	0
5	XXXX	XXXX	Elective - V	3+1	3	1
Total Credit Hours in Semester-8				16	11	5

Total Credit Hours: 131

List of Courses

Computing Courses (3 credit hours)

Sr. No	Pre-req	Course Code	Course Title	Theory	Lab	CR
1	None	CSC 112	Programming Fundamentals	2	1	3

Mathematics and Supporting courses (12 credit hours)

Sr. No	Pre-req	Course Code	Course Title	Theory	Lab	CR

1	None	MAT 121	Applied Mathematics-I	3	0	3
2	MAT 121	MAT 122	Applied Mathematics - II	3	0	3
3	MAT 121	EEN 226	Probability Methods in Engineering	3	0	3
`4	MAT 122	GSC 320	Numerical Analysis	3	0	3

General Education Courses (13 credit hours)

Sr. No	Pre-req	Course Code	Course Title	Theory	Lab	CR
1	None	GSC 113	Applied Physics	3	1	4
2	None	ISL 101/ HSS 116	Islamic Studies/Ethics	2	0	2
3	None	ENG 100	English-I	2	0	2
4	None	PAK 101	Pakistan Studies	2	0	2
5	None	ENG 320	Technical Report Writing and Presentation Skills	3	0	3

Power & Renewable Energy Core Courses (72 credit hours)

Sr. No	Pre-req	Course Code	Course Title	Theory	Lab	CR
1	None	ENV 440	Energy and Environment	2	0	2
2	None	GSC 115	Circuit Analysis	3	1	4
3	None	ESC 111	Basic Mechanical Engineering	2	0	2
4	None	EEL 112	Workshop Practice	0	1	1
5	None	EEL 121	Engineering Drawing & CAD	0	1	1
6	None	CEN 120	Digital Logic Design	3	1	4
7	GSC 115	EEN 312	Electrical Machine	3	1	4
8	GSC 115	EEN 224	Electronic Devices & Circuits	3	1	4
9	None	EEP 448	Renewable Energy Systems	3	0	3
10	EEN 224	EEP 468	Power Electronics	3	1	4
11	GSC 115	EEN 433	Powe Distribution and Utilization	3	1	4
12	CEN 120	CEN 440	Embedded Systems Design	3	1	4
13	GSC 115	EEP 331	Power System Analysis	3	1	4
14	EEN 224	EEN 316	Instrumentation & Measurements	3	1	4
15	None	EPS-324	Energy Conservation and Auditing	3	0	3
16	None	EPS 345	Bio-Energy System	2	0	2
17	EEP 448	EPS 378	Integration of Distributed Power	3	1	4

			Generation			
18	CEN 120	CEN-354	Programming for DSP/FPGA	3	1	4
19	EEP 331	EEP 444	Power System Protection	3	1	4
20	EEN 312	EEP 475	FACTs and HVDC Transmission	3	1	4
21	None	EPS-220	Energy Economics, Policy, and Managements	2	0	2
22	None	XXXX	Project -I	0	3	3
23	None	XXXX	Project -II	0	3	3

Social Science Course (3 credit hours)

Sr. No	Pre-req	Course Code	Course Title	Theory	Lab	CR
1	None	HSS 422	Engineering Ethics	3	0	3
2	None	HSS 202	Introduction to Sociology	3	0	3
3	None	BES 103	Critical Thinking	3	0	3
4	None	HSS 456	Organizational Behavior	3	0	3
5	None	HSS 111	Introduction to International Relations	3	0	3

Management Science Course (8 credit hours)

Sr. No	Pre-req	Course Code	Course Title	Theory	Lab	CR
1	None	MGT 425	Project Management in Engineering	3	0	3
2	None	MGT 437	Total Quality Management	3	0	3
3	None	MKT 422	Business Planning in Energy System	2	0	2

Power & Renewable Energy Electives Courses:

S. No.	Pre-requisite course code	Course Code	Course Title	Credit Hours	Theory	Practical
1	None	EEP 446	High Voltage Engineering	3+1	3	1
2	EEP 468	EPS 455	Control of Power Electronics System	3+1	3	1
3	None	EPS 422	Hydropower and Energy Storage Technologies	3+1	3	1
4	EEP 448	EPS 434	RS & GIS for Renewable Energy Resources	3+1	3	1
5	MAT 122	EEN 412	Linear Control System	3+1	3	1
6	EPS 378	EPS 421	Smart Grid System	3+1	3	1
7	None	EPS 456	Modelling and Optimization of Energy Systems	3+1	3	1
8	EEN 433	EEP 443	Electrical Power Transmission	3+1	3	1
9	GSC 113	EPS 411	Heating, Ventilation, and Air Conditioning Systems	3+0	3	0
10	None	EPS 424	Production Planning and Control	3+0	3	0
11	None	EPS 444	Energy in Transportation	3+0	3	0
12	None	EPS 454	Manufacturing Engineering	3+0	3	0

13	GSC 113	EPS 431	Hydrogen and Fuel Cell	3+0	3	0
14	GSC 113	EPS 432	Combine Heat and Power Energy System	3+0	3	0
15	EEP 448	EPS 433	Geothermal and Tidal Energy	3+0	3	0
16	GSC 113	EPS 435	Nuclear Energy Engineering	3+0	3	0
17	None	EPS 436	Conventional Power Generation Systems	3+0	3	0
18	EEN 412	EEP 445	Power System Stability & Control	3+0	3	0

Appendage-2902B

COURSE OUTLINES

1. Electrical Power Transmission

Course Code: EEP 443
Credit Hrs.: 3+1
Pre-Requisite: Power Distribution and Utilization

Objectives: The course presents basics of electrical power transmission along with electrical and mechanical design impacts on power transmission in detail and HVDC transmission is introduced.
Course Outline: Percent and per-unit quantities, selection of base and change in base of per unit quantities, node equations, one-line diagram, choice of voltage and choice of AC/DC systems, economic comparison of various transmission systems, standard voltages in Pakistan and abroad for transmission and sub-transmission. Introduction to HV, EHV and UHV system. Conductor types; resistance, skin 48 effect, line inductance based and flux considerations. Inductance of single phase and three phase lines, inductance of composite conductor line, inductance of bundled conductors, capacitance of single phase and three-phase lines, effect of earth on capacitance, capacitance of bundled conductors, parallel circuit lines, Ferranti effect. Short, medium and long transmission lines, solution of equations. Traveling waves, surge impedance loading, equivalent circuit, and power flow through the line, voltage regulation and line surges. Line supports, sag and tension calculation, total length of conductor supports at various levels, mechanical degree of safety, effect of wind pressure and ice loading, conductor vibration and use of dampers. Insulator material, types of insulators, voltage distribution over insulator string, string efficiency, methods of improving the string efficiency, testing of insulators, corona effect, corona loss, radio interference due to corona. Underground cables: types, calculation of inductance and capacitance, insulation resistance, insulation breakdown of cables, thermal characteristics of cables, calculation of current rating of the cables, fault locating techniques, cable jointing techniques. Introduction and classification of HVDC transmission.
Recommended Book(s):

1. Stevenson, "Elements of Power System", Latest Edition.
2. Grainger and Stevenson, "Power System Analysis", Latest Edition.

2. Electrical Machines

Course Code: EEN 312
Credit Hrs.: 3+1
Pre-Requisite: Circuit Analysis

Objectives: Covers detailed and in-depth aspects of Electrical Machines.
Course Outline: Transformers: Equivalent Circuit, per unit system of measurement, voltage regulation and efficiency, three phase transformers, types of connections, testing, and parallel operation.

Synchronous Generators: Equivalent circuit and operations, Characteristics of Salient and Non-Salient poles, model parameters, Single and parallel operation, ratings. Synchronous Motors: Basic Principle, Equivalent Circuit, steady state operation: Torque speed characteristics, power factor correction, starting of synchronous motors, ratings, speed control. Induction Motors: Production of rotating field and torque, Construction, Synchronous speed, Slip and its effect on rotor frequency and voltage. Equivalent circuit. Power and torque. Losses, efficiency and power factor. Torque-speed characteristic. Starting and speed control. Induction generator. Lab Outline: Based on above course contents

Recommended Book(s):

1. Stephen J. Chapman, "Electric Machinery Fundamentals", McGraw-Hill. (Latest Edition)
2. Hubert, "Electric Machines Theory, Operation, Applications, Adjustment and Control", (Latest Edition).

3. Conventional Power Generation Systems

Course Code: EPS 436
Credit Hrs.: 3+0
Pre-Requisite: None

Objectives: The students learn different power plant and modes of energy conversion to generate electrical energy in this course and the concepts of fuel cells are introduced.

Course Outline: Thermal Power Plants: Sources of conventional energy and method of harnessing, specific features and cycles used in steam, gas and diesel power plants, combine cycle systems and cogeneration. Location of the above plants and selection of units, prime movers and associated equipment. Hydroelectric Power Plants: The plants and their equipment, layouts, run of the river and accumulation type station, types of hydroelectric turbines and their stations. Nuclear Power Plants: 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 generators, figure of merit, device configuration, solar and radioisotope powered generators, applications. MHD Generators: Gaseous conductors, analysis and design of MHD generator, problems associated with MHD generation, possible configuration. Photovoltaic Generators: Radiation principles, optical effects in semiconductors and PN junction, analysis and design of converter, fabrication of cells, solar cells in space. Fuel Cells: Thermodynamic principles, efficiency of fuel cell factors limiting the performance, design, new development in fuel cells, possibility of future use in electric vehicles. Wind power generation.

Recommended Book(s):

1. Arche W. Culp, "Principles of Energy Conversion", Latest Edition.
2. M.M. Wakel, "Power Plant Technology", McGraw-Hill, Latest Edition.

4. Energy in Transportation

Course Code: EPS 444
Credit Hrs.: 3+0
Pre-Requisite: None

Objectives: Students are introduced to the basics of electrical distribution systems for transportation.

Course Outline: Introduction to distribution system. Urban, suburban and rural distribution systems. Primary, secondary and tertiary voltages. Radial and ring main systems, application of distribution transformers, estimation of load, load characteristics, substation switch gears and bus bar arrangements, calculation of voltage drop and regulation in distribution feeders. Grounding and earthing, distribution transformer neutral, earthing resistance, earthing practice in L.V. networks. Power Factor: Disadvantages and causes of low power factor, methods for improvement, application of shunt capacitors in distribution network. Batteries & Electrochemical Processes: Main types of batteries and their working, battery charging, electroplating, electrolysis and electro-metallurgical process. Cathodic protection of poles, gas pipes, oil pipes and water structures. Heating and Welding: Electric heating, resistance, induction and dielectric heating, electric furnaces, microwave heating,

electric welding, resistance welding and its types. Fundamentals of Illumination Engineering: 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.), types of lamps, their working and relative merit.

Recommended Book(s):

1. M. L. Anand, "A Text Book of Electrical Power", Latest Edition.
2. Turan Gonen, "Electrical Power Distribution System", Latest Edition.

5. Power System Analysis

Course Code: EEP 331
Credit Hrs.: 3+1
Pre-Requisite: Circuit Analysis

Objectives: This course has been designed to introduce the importance of analyzing various aspects of power system. It covers power flow studies and fault analysis of both symmetrical and unsymmetrical faults in power networks. This forms the basis for power system operation, control and protection.

Course Outline: The Admittance Model and Network Calculations: Branch and Node admittances; Mutually coupled Branches in Y-bus; Equivalent Admittance Network; Modification of Y-bus; Impedance matrix and Y-bus; the method of successive elimination; Node Elimination (Kron Reduction); Triangular Factorization. The Impedance Model and Network Calculations: The bus, admittance and impedance Matrices; Thevenin's Theorem and Z-bus; Modification of an existing Z-bus; Direct determination of Z-bus; Calculation of Z-bus elements from Y-bus; Power Invariant Transformations; Mutually coupled branches in Z-bus. Symmetrical Faults: Transients in RL circuits; internal voltages of loaded machines. Under fault conditions; fault calculations using Zbus; Equivalent circuits; Selection of circuit breakers. 45 Symmetrical Components and Sequence Networks: Synthesis of unsymmetrical phasors; symmetrical components of unsymmetrical phasors; Networks of a symmetrical Transmission line; sequence Networks of the synchronous Machines; Sequence Networks of Y-impedances; sequence networks; positive, negative and zero sequence networks; Unsymmetrical Faults: Unsymmetrical faults on power systems; single line-to-ground faults; line-to-line faults. Double line-to-ground faults; Demonstration problems; open conductor faults.

Recommended Book(s):

1. B. S. William, "Elements of Power System Analysis", McGraw Hill, Latest Ed.
2. B. M. Weedy, "Electrical Power Systems", Pergamon Press, Latest Ed.
3. Hadi Saadat, "Power System Analysis", Latest Ed.

6. Power System Protection

Course Code: EEP 444
Credit Hrs.: 3+1
Pre-Requisite: Power System Analysis

Objectives: The course presents diverse types of relays, relaying schemes, circuit breakers and fuses. Topics like discrimination and coordination are also introduced.

Course Outline: Introduction to protection system, types of faults, effect of faults, fuse as protective device, types of fuses, characteristics of fuses, selection and application of fuses, discrimination and coordination, current transformer and its operation, relay construction, basic relay terminology, electromagnetic relays, thermal relays, static relays and introduction to microprocessor based protective relays, over current protection, distance protection, impedance relay, R-X 47 diagram of impedance relay, operation of impedance relay in different zones, reactance relay, differential protection of transformers, generator protection, bus bar protection, arc voltage, arc interruption, re-striking voltage and recovery voltage, resistance switching, current chopping circuit breaker, classification of circuit breakers, oil circuit breakers, air blast circuit breakers, air break circuit breakers, SFB6B circuit breakers, vacuum circuit breakers, operational mechanism and rating of circuit breakers.

Recommended Book(s):

1. S. Rao, "Switchgear and Protection", Khanna Publisher, Latest Edition.

2. Paithanker & Bhide, "Fundamentals of Power System Protection", Prentice Hall, Latest Edition.

7. High Voltage Engineering

Course Code: EEP 446
Credit Hrs.: 3+1
Pre-Requisite: None

Objectives: The demand for the generation and transmission of copious amounts of electric power today, necessitates in transmission at extra-high voltages. At this juncture, a practicing electrical engineer or a student of electrical engineering is expected to possess knowledge of high voltage techniques and should have sufficient background in high voltage engineering. Upon completion of this course, the participant shall be able to understand high voltage basics and its application appreciate the design principles and critical elements of a high voltage system.

Course Outline: Introduction, testing voltages, Generation of High Voltages, Measurements of High Voltages, Electrostatic Field and field stress control, Breakdown Mechanism of Gases, Breakdown in Solids and Liquids, Breakdown in Solids and Liquids, Non-destructive testing technique, Over voltages, Testing procedure and insulation coordination, Over voltages, Testing procedure and insulation coordination, Transients in Power Systems

Recommended Book(s):

1. High Voltage Engineering by C.L Wadwa

Recommended Text(s)/Reference Books:

2. High Voltage Engineering by M S Naidu
3. High Voltage Engineering Fundamentals by E. Kuffel

8. Renewable Energy Systems

Course Code: EEP 448
Credit Hrs.: 3+0
Pre-Requisite: None

Objectives: Students are introduced to different types of renewable energy resources by engaging in various activities to help them understand the transformation of energy (solar, water, nuclear, biomass and wind) into electricity. Students explore the different roles engineers who work in renewable energy fields have in creating a sustainable environment – an environment that contributes to greater health, happiness and safety.

Course Outline: Promising renewable energy sources, their potential availability and present status, existing technologies and availability, solar energy: Sun-Earth relationship, solar geometry, sun path and solar irradiance, solar spectrum. Solar constant, atmospheric effects, global distribution, effects of tilt angle, daily and seasonal variations, resource estimation. Extraterrestrial, global, direct, diffused radiation, Flat plate collectors, their designs, heat transfer, transmission through glass, absorption transmission of sun energy, selective surfaces, performance, and efficiency, Photovoltaic: PV effect, materials, solar cell working, efficiencies, different types of solar cells, characteristics, (dark, under illumination), efficiency limiting factors, power spectral response, fill factor, temperature effect; PV systems, components, modules, arrays, controllers, inverters, storage, PV system sizing, performance and applications, Wind: Global distribution, resource assessment, wind speed, height and topographic effects, power extraction for wind energy conversion, wind mills, their types, capacity, properties, wind mills for water lifting and power generation, environmental effect., Hydropower: Global resources, and their assessment, classification, micro, mini, small and large sources principles of energy conversion; turbines, their working and efficiency for micro to small power systems, environmental impact, Biogas: Biomass sources; residue, farms, forest. Solid wastes; agricultural, industrial and municipal wastes etc.; applications, traditional and nontraditional uses: utilization, process, gasification, digester, types, energy forming, Environment issues, Geothermal: Temperature variation in the earth, sites, potentials, availability, extraction techniques, applications; water and space heating, power generations, problems, environmental effects, nuclear: Global generations of reserves through reprocessing and breeder reactors, growth rate prospect of nuclear fusion, safety and hazards issue.

Recommended Book(s):

1. Manfred Grathwhol. World Energy Supply: Resources, Technologies and Prospective, Walter de Gruyter-Berlin, Latest edition
2. J.W Twidell and A.D. Weir. Resources, E & F.N. Spon Ltd, London, Latest edition
3. M Iqbal. An Introduction to Solar Radiation, Academic Press, Canada, Latest edition
4. Simon Roberts. A Practical Guide to Solar Electricity, Prentice Hall, Latest edition
5. Martin A G. Solar cells: Operating Principles, Technology, & System Application, Prentice Hall, Latest edition
6. T.J. Jansen. Solar Engineering Technology, Prentice Hall, Latest edition
7. Daniel H' Wind Power. A Book on Wind Energy Conversion System, Litton Educational Press, Latest edition

9. Energy and Environment

Course Code: ENV 440
Credit Hrs.: 2+0
Pre-Requisite: None

Objectives: This course examines the scientific and engineering aspects of energy production, transformation, and consumption, investigates the energy flows in the Earth's systems, and provides students with necessary engineering approaches and techniques for understanding, assessing, and remediating environmental problems associated with energy production, transformation, and consumption.

Course Outline: Introduction: Getting Power to the People (Energy and Environment); Sources of energy, Renewable and non-renewable energy resources, Economics of energy production and consumption Global Politics and Strategies, Making global and local decisions on the structure of utilized energy sources, Energy and Society; Thermodynamic Principles of Energy Conversion; Flue gases, NOx formation and reduction, Combustion emission control, Thermodynamic fundamentals, Natural gas combustion, Coal combustion, Estimating steam power; Global Energy Use and Supply, Renewable resources and fossil fuels, Hydraulic, geothermal, wind, tidal, solar, biomass energies, Oil, gas, coal, and oil shale energy production, Environmental consequences of the fossil fuels production and utilization; Nuclear Energy; Fundamentals of nuclear power, Nuclear power systems, Comparing fission and fusion energies, Nuclear power health effects, Safety requirements for nuclear power plants, Radioactive waste management and disposal; Alternative Fuels and Advanced Technologies (Renewable Energy).

Recommended Book(s):

1. James A. Fay and Dan S. Golomb, 2002, Energy and the Environment, OXFORD University Press, 198 Madison Avenue, New York, NY, 10016.
2. On Global Forces of Nature Driving the Earth's Climate. Are Humans Involved, by L.F. Khilyuk and G.V. Chilingar, 2006, Environmental Geology, 50: 899-910

10. Integration of Distributed Power Generation

Course Code: EPS 378
Credit Hrs.: 3+1
Pre-Requisite: Renewable Energy Systems

Objectives: The course has been designed to help students understand the concept of distributed generation. The course will also enhance the skill of students to analyses the impact on grid integration & to study concept of microgrid and its configuration.

Course Outline: Introduction to distribution generation system, renewables application as distribution sources, concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements.

Requirements for grid interconnection, limits on operational parameters, voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues. Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids, Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics.

Recommended Book(s):

1. Integration of Distributed Generation in the Power System by Math Bollen And Fainan Hassan
2. Voltage Source Converters in Power Systems: Modeling, Control and Applications", Amir naserYezdani, and Reza Iravani, IEEE John Wiley Publications.
3. "Power Switching Converters: Medium and High Power", Dorin Neacsu, CRC Press, Taylor & Francis, 2006.

11. Energy Conservation and Auditing

Course Code: EPS 324
Credit Hrs.: 3+0
Pre-Requisite: None

Objectives: This course provides students with a good theoretical knowledge and understanding of power system economics. The basic principles of power system economics (main regulatory regimes and pricing principles) will be analysed in order to combine power system analysis and economic appraisal, providing an insight and ability to estimate future developments. Technical and economic implications of transition to a low-carbon energy systems will be discussed.

Course Outline: Power market fundamentals; pricing power, energy, and capacity; power supply and demand; Marginal cost in a power market; Market structure; Reliability and investment policy; reliability and generation; operating reserve pricing; requirement of installed capacity; Market architecture; day ahead market design; ancillary services; Market for operating reserves; defining Market power, modelling market power.

Recommended Book(s):

1. Power System Economics: Designing Market for Electricity by Steven Stoft
2. Fundamentals of Power System Economics by Daniel S. Kirschen, Goran Strbac

12. Modelling and Optimization of Energy Systems

Course Code: EPS 456
Credit Hrs.: 3+1
Pre-Requisite: None

Objectives: Students will understand the operation of power networks from a control and optimization perspective. They will learn how mathematical tools and computational methods are used for the design, modelling, planning, and real-time operation of power grids.

Course Outline: Introduction to optimization, Meaning of optimization, Types of problems, Linear programming, Basic solution, Simplex method and LU decomposition, Unconstrained optimization, Minimization and maximization of convex functions, Gradient descent method, Method of steepest descent, Newton's method, Multi objective optimization problems, Evolutionary optimization algorithms, Economic Dispatch, DC Optimal Power Flow, AC Optimal Power Flow, Power optimization problems such as state estimation, unit commitment, optimal power flow, and transmission planning, Efficient optimization and numerical algorithms for mixed-integer nonlinear problems, Control and optimization for renewable energy, Unit commitment.

Recommended Book(s):

1. An Introduction to Optimization by E.K. Chong and S.H. Zak, Wiley-Interscience.

2. Convex optimization Stephen Boyd, and Lieven Vandenberghe, Cambridge university press, 2004.
3. Allen J. Wood, Bruce F. Wollenberg, and Gerald B. Sheble, Power Generation, Operation, and Control (3rd edition), Wiley, 2013.

13. Power System Stability & Control

Course Code: EEP 445
Credit Hrs.: 3+0
Pre-Requisite: None

Objectives: Various aspects of power system operation, monitoring and control are covered with an emphasis on SCADA systems.
Course Outline: Steady state and transient stability problems of multi-machine interconnected systems, Swing equation, and point-by-point solution of swing equation. Equal area criterion, one machine and two-machine systems, Critical fault clearing time. Effect of fault on stability, Stability study of typical Power systems. Introduction to power system control and its importance, modes of power system operation, major tasks of operation. SCADA system, control centres, controller tuning, communication sub system, remote terminal unit, data logging. Economic dispatch, characteristics of power generation units, economic dispatch problems with and without consideration of losses, incremental fuel cost, penalty factor, economic power interchange. Voltage, power and frequency control. Evaluation of the effect of speed change on droop characteristics.
Recommended Books:

1. Woolen Barg, "Power Generation, Operation and Control", Latest Edition.
2. Trosten Cegral, "Power System Control Technology", Latest Edition.
3. P. Kundur, "Power System Stability and Control", Latest Edition.

14. Smart Grid System

Course Code: EPS 421
Credit Hrs.: 3+1
Pre-Requisite: Integration of Distributed Power Generation

Objectives: The objective of the course is to develop a broader understanding of Smart Grid and familiarize the students regarding the existing smart grid technologies. The course will also focus on the applications of smart grid and give awareness of modern, affordable, and sustainable energy.
Course Outline: Smart grid basics: Overview of existing grid, why do we need smart grid, Objectives and main features of Smart Grid, Current status of smart grid technology, Future of Smart Grid, advantages and Disadvantages, Implementation of smart grid and possible difficulties. Distributed Generation: Overview of Distributed Generation, New paradigm of power generation, future power grid, Impact of Distributed Generation on the main power grid, Smart Grid and Distributed Generation: Advantages and Disadvantages, Challenges for load flow studies, Load flow analysis in smart grid environment. Demand side management: Introduction, types and tools for demand side management, Demand response and its applications, Types of loads & their current signatures, Smart Meters. Micro networks. Converter control, Micro-network simulation, Communication Technology for Smart Grid: Basics of Data communication technology, Communication protocols. Power System Monitoring and Control, Architecture and application of SCADA (Supervisor Control and Data Acquisition).
Recommended Books:

1. Power System Analysis by Hadi Saadat McGraw-Hill International Editions
2. The Smart Grid: Enabling Energy Efficiency and Demand Response by Clark W. Gellings, P.E.
3. Synchronized Phasor Measurement Units and their applications by A.G Phadke, J.S Thorp

15. Nuclear Energy Engineering

Course Code: EPS 435
Credit Hrs.: 3+0

Pre-Requisite: Applied Physics

Objectives: This course will give the student basic understanding of nuclear process in fission and fusion reaction, analyze the advanced nuclear reactor systems and the sustainable development of innovative nuclear energy technologies, and be able to explain the concepts of radioactive waste management for nuclear energy application.

Course Outline: Role and importance of nuclear energy, Particle wavelength, Excited states and radiation, Nuclear stability and radioactive decay, Nuclear reaction, Binding energy, Mass deficit Radioactive decay, Interaction of radiation with matter: Neutron interaction, Cross-sections, Neutron attenuation, Neutron flux, Neutron cross-section data, Energy loss in scattering collision, Fission, γ-ray interaction with matter, Nuclear reactor: Fission chain reaction, Nuclear reactor fuel, Nuclear power plants Nuclear Reactor Systems and components: Steam generator, Pressurizer, Steam supply system, Reactor Containment, Turbine, Cooling Tower; Nuclear Detectors: Neutron flux, Fick's law, Equation of continuity, Diffusion equation, heat Removal from reactor, Heat generation in reactors, Conduction, Convention, Two Phase Flow, Boiling Heat transfer, Nuclear reactor safety: Reliability, Risk, Safety

Recommended Books:

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

16. Geothermal and Tidal Energy

Course Code: EPS 433
Credit Hrs.: 3+0
Pre-Requisite: Renewable Energy Systems

Objectives: This course will give the student the knowledge of geothermal energy, tidal and wave energy conversion system. Issues and problems for successful exploration of geothermal and tidal will be analyzed.

Course Outline: Geology of Geothermal Regions, Exploration Strategies and Techniques Principles, Heat source systems for ambient air utilization, Heat source systems for shallow geothermal utilization, Geothermal well drilling, Design of down hole part, Up hole part system, District heating system, Environmental analysis of geothermal energy, Case study related to geothermal energy, Steam Power Plants, Single and double flash steam power plants, Binary cycle power plants, Advanced geothermal energy conversion systems, Exergy analysis applied to geothermal power systems, Tidal and wave energy, Tidal and wave energy conversion systems.

Recommended Books:

1. Pimental, D. and R. DiPippo. 2008. Geothermal Power Plants, 2nd Ed. Elsevier. USA.
2. Charlier, R.H. and W.Finkl. 2009. Ocean Energy Tide and Tidal Power. 1st Ed. Springer.
3. Brooke, J. 2003. Wave Energy Conversion. 1st Ed. Vol- 6. Elsevier Ocean engineering.

17. Hydrogen and Fuel Cells

Course Code: EPS 431
Credit Hrs.: 3+0
Pre-Requisite: None

Objectives: This course will give the student knowledge of hydrogen systems, storage, production and its application in fuel cells. Hydrogen energy system for use with fuel cells systems will be analyze.

Course Outline: Fuel-cell technologies, possible fuels, and their applications, Hydrogen as Future Energy Carrier. Hydrogen Fuel Cell Engines and Technologies, Hydrogen Properties, thermal,

electrolytic, Photolytic processes of hydrogen decomposition. Hydrocarbon Decomposition water decomposition. Hydrogen Distribution, Hydrogen Storage. Hydrogen Use in Internal Combustion Engines; Hydrogen feeding system, air feeding system, thermal management system, Integrated Fuel Cell System. Hydrogen feedstock and basics of its reforming; Fuel Cell Principles; Introduction to fuel cell types, basic principles; Polarization curve, Fuel cell thermodynamics; Fuel cell reaction kinetics; Charge transfer in fuel cells; Mass transport in fuel cells; Fuel cell characterization, Fuel reforming technologies, types of fuel reformers, Overview of fuel cell types; Proton exchange membrane and solid oxide fuel cell materials

Recommended Books:

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

18. Hydropower and Energy Storage Technologies

Course Code: EPS 422
Credit Hrs.: 3+1
Pre-Requisite: None

Objectives: To develop in the students the capability to understand, design, develop and implement hydro-power plants. Course will also cover the technologies needed to energy storage.

Course Outline: 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. Energy storage: pumped storage facilities. Economic analysis and environmental considerations,

Recommended Books:

1. Du, P. and N. Lu. Energy Storage for Smart Grids: Planning and Operation for Renewable and Variable Energy Resources (VERs). Academic Press, USA, Latest edition
2. Wagner, H.J. and M. Jyotirmay. Introduction to Hydro Energy Systems, Springer Verlag Berlin Heidelberg, Latest edition
3. Godfrey Boyle. Renewable Energy, Power for a Sustainable Future, Oxford University Press, U.K., Latest edition

19. Bio Energy Systems

Course Code: EPS 345
Credit Hrs.: 2+0
Pre-Requisite: None

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

Course Outline: 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.

Recommended Books:

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.

20. Manufacturing Engineering

Course Code: EPS 454
Credit Hrs.: 3+0
Pre-Requisite: None

Objectives: To acquaint the students with the knowledge of manufacturing processes, computer aided manufacturing (CAM) and computerized numerical control (CNC) machines and understand the concepts of manufacturing techniques for industrial applications.

Course Outline:

Introduction to lathe machines. Turning and related operations. Types and construction of lathe and its accessories. Lathe operations, Turret lathe and turret lathe tooling, Mechanism of chip formation. Type of cutting tools and their materials Tool failure, tool life and use of coolants. Drilling and Reaming. Type of drilling machines, drill bits and drill chucks. Counter boring and sinking, boring and reaming practices and tools. Estimating drilling time, Milling machines. Types and working principle of milling machines. Milling operations and mill cutters. Estimating milling time. Shaping and Planning. Types of shaper and planers and their applications. Shaper drive mechanism. Shaper speeds and machining times. Construction and types of planning machines. Planer tools and work set up methods. Metal bending and sheet rolling processes. CAD and CIM Systems. Computer aided manufacturing and computer integrated manufacturing systems. Type of CNC machines and their working principles. Programming for numerical control. Machine tool control. Welding processes. Classification and application of welding processes. Oxyacetylene gas welding (OAW). Shielded metal arc welding (SMAW). Designation system for arc welding electrode. Resistance spot welding (RSW). Resistance seam welding (RSW) Forge welding (FOW). Weldability and weld quality. Weld design and process selection

Recommended Books:

1. Kalpakjian, S. and S. Schmid. 2007. Manufacturing Processes for EngEd. Pearson Education, New Delhi. India.
2. Kalpakjin, S. and R.S. Schmid. 2004. Manufacturing engineering and tecMcGraw Hill Co. Ltd, New Delhi. India.
3. Ostwald, P.H. and J. Munoz. 2002. Manufacturing Processes and SWiley and Sons, New York. USA.

21. RS & GIS for Renewable Energy Resources

Course Code: EPS 434
Credit Hrs.: 3+1
Pre-Requisite: Renewable Energy Systems

Objectives: The course will give the student the knowledge of coordinate system projections and geo-referencing, analyze and interpret satellite imaging for site selection and be able to demonstrate the use of RS and GIS software for identifying potential zones to harness energy.

Course Outline:

Introduction to Global positioning system (GPS), Satellite imagery, Introduction to RS & GIS, Example applications of RS & GIS. Coordinate systems and projections, geo-referencing and scale generalization GIS, Raster and vector data set, Use of GPS and DGPS, Data import and export, Open existing tables, Creating new tables, Drawing objects on a map, Creating and using layouts. Spatial interpolation and geo-station. Spatial data analysis, spatial statistics, Terrain analysis and assessment. Vector to raster and vice versa, RS Satellite data acquisition. Image processing. Image interpretation. Site identification for solar system installation, wind energy set up and hydropower energy.

Recommended 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.

22. Energy Economics, Policy, and Management

Course Code: EPS 220
Credit Hrs.: 2+0
Pre-Requisite: None

Objectives: The course will give student the understanding of the Pakistan current energy and environmental situation and policies. The course will cover the basics of energy economic and project management and analyze the sustainability of energy projects.

Course Outline:

Pakistan's Energy and Environmental Profile Pakistan's energy supply-demand situation. Pakistan's energy related greenhouse gas (GHG) emissions. Impact of energy on economy, development and environment. Energy for sustainable development and need for use of new and renewable energy sources. Energy sources and overall energy demand and availability. Energy consumption in various sectors and its changing pattern. Exponential increase in energy consumption and projected future demands. Energy Economics and Management. Basics of supply, demand and price formation in competitive markets. Energy demand: short run and long run price and income elasticities. Introduction to single variate and multi variate regression analysis, Cost of power plant, structure of power tariffs. Concept and theory of management, methods and processes of management, Introduction to smart grid (On- and Off- grid system), Introduction to project management,. Energy contracts & preparation of PCs, Regulatory bodies, NEPRA, OGRA, PPIB. Net-metering, Feed-in-tariff policy. Financial management and introduction to accounting, auditing, cash flow terms, Estimation of economic and financial rates of return, prices, wages, profit and interest. Pakistan's Energy and Environmental policies. Overview of Pakistan's oil, gas and power policies. Sustainability analysis of energy policies and reasons for failure of energy policies. Sustainability analysis of energy projects. Energy diplomacy, Energy Security, Energy diversity. Depletion of energy sources and their impact on economies of countries and on international relations. International Energy and Environmental treaties (Rio, Montreal, Kyoto, Paris). Pakistan's Intended Nationally Determined Contributions

(INDCs). Energy investments under China-Pakistan Economic Corridor. Impacts of coal related investments under CPEC on energy and environment profile of Pakistan

Recommended 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

23. Total Quality Management

Course Code: MGT 437
Credit Hrs.: 3+0
Pre-Requisite: None

Objectives: To enable students to develop quality management skills.

Course Outline:

Introduction to Quality: Quality concepts, types and aspects, Significance of quality. Commitment and Leadership: Commitment and Policy, Creating or changing the culture, effective leadership. Quality Planning: Flow charting, process charting, purchase planning, planning for JIT. Design for Quality: Innovation, Quality Function Deployment and the house of Quality. Quality Related Costs: Prevention, Appraisal and Failure Costs, Models for Quality Costing. Quality Measurement: Significance, Methods, Tools and Techniques for Quality Improvement: Basic Tools, Advanced Tools.- Quality Management System (ISO 9000 series): Significance, Documentations, Implementation and Certification, Audits, Expected Problems. Environmental Management System (ISO 14000 series): Significance, Documentations, Implementation and Certification, Audits, Expected Problems.

Recommended Books:

1. Oakland J. S. TOTAL QUALITY MANGEMENT, Bulterworth Heinemann Ltd. UK.
2. ISO 9000 series of standards
3. ISO 14000 series of standards
4. Feigenbaum, TOTAL QUALITY CONTROL. McGraw Hill Book

24. Programming for DSP/FPGA

Course Code: CEN 354
Credit Hrs.: 3+1
Pre-Requisite: Digital Logic Design

Objectives: After completion of this course students should be able to: Fully understand the fundamental of designing techniques. Gain knowledge to design digital system. Understand fully the Hardware Description Language (HDL). Use HDL to design hardware components and systems. Gain sufficient knowledge to simplify a complex logic design using software tools. Acquire sufficient knowledge and inner working of programmable logic devices. Implement the designs and verify the complete system.

Course Outline:

Course organization and requirements, Overview of digital systems design, testing and verification. Hardware Description Languages (HDL); Selection of HDL Language, Fundamentals of the Language, Design and Modeling Recommendations , Design Simulation, Synthesis of Designs 3. Design Implementation Technologies; Programmable Array Logic, Programmable Logic Array, Complex Programmable Logic Devices (CPLD), Field Programmable Gate Array (FPGA)Technologies. System Arithmetic Algorithms and Hardware Designs. Electronic Design Automation; Usage of CAD Tool, Programmable Device Design Flows. Physical Design Automation -- Systems; Partitioning; Placement; Routing. Clock Design Considerations -- Timing Margins, Clock Skew, Clock Distribution. Logic Circuit Testing and Testable Design; Design of a test bench, Digital Logic Circuit Testing and Test Vector Generation, Combinational and Sequential Logic Circuit Testing.

Recommended Books:

1. Wayne Wolf, "FPGA-Based System Design," with CD-ROM, 2004, Prentice Hall, ISBN: 0131424610.
2. Samir Palnitkar, "Verilog HDL", Prentice Hall, ISBN: 0130449113.
3. Michael D. Ciletti, "Advanced Digital Design with the Verilog HDL", Prentice Hall, ISBN: 0130891614.

25. Applied Mathematics-I

Course Code: MA 121
Credit Hrs.: 3+0
Pre-Requisite: None

Objectives: This course will cover the basic of complex variables, and calculus.

Course Outline:

Complex numbers, Argand diagram, De Moivre‟s theorem, hyperbolic and inverse hyperbolic functions. Algebra of vectors and matrices, systems of linear equations. Derivative as slope, as rate of change (graphical representation). Extreme values, tangents and normals, curvature and radius of curvature. Differentiation as approximation. Partial derivatives and their application to extreme values and approximation. Integration by substitution and by parts, integration and definite integration as area under curve (graphical representation). Reduction formulae. Double integration and its applications. Polar and Cartesian coordinates, polar curves, radius of curvature, cycloid, hypocycloid, epicycloids and involutes of a circle..

Recommended Books:

1. Calculus and analytical Geometry, 11th Edition By Thomas Finney John Wiley & Sons.
2. Advanced Engineering Mathematics 5th Edition By C. R. Wylie McGraw-Hill Education.
3. Advanced Engineering Mathematics, 8th Edition By HTErwin Kreyszig TH John Wiley & Sons.

26. Applied Mathematics-II

Course Code: MAT 122
Credit Hrs.: 3+0
Pre-Requisite: 26. Applied Mathematics-I

Objectives: This course will cover the basic of differential equations, and Laplace transform.

Course Outline:

Differential equation; basic concepts and ideas; geometrical interpretation of first and second order differential equations; separable equations, equations reducible to separable form, exact differential equations, integrated factors. Linear first order differential equations, Bernoulli‟s differential equation. Families of curves, orthogonal trajectories and applications of differential equations of first order to relevant engineering systems. Homogeneous linear differential equations of second order, homogeneous equations with constant coefficients, the general solutions, initial and boundary value problems, D-operator, complementary functions and particular integrals. Real, complex and repeated roots of characteristics equations. Cauchy equation, non-homogeneous linear equations. Applications of higher order linear differential equations. Ordinary and regular points and corresponding series solutions; introduction to Laplace transformation..

Recommended Books:

1. Calculus and analytical Geometry, 11th Edition By Thomas Finney John Wiley & Sons.
2. Advanced Engineering Mathematics 5th Edition By C. R. Wylie McGraw-Hill Education.
3. Advanced Engineering Mathematics, 8th Edition By HTErwin Kreyszig TH John Wiley & Sons.

27. Control of Power Electronics System

Course Code: EPS 455
Credit Hrs.: 3+1

Pre-Requisite: Power Electronics

Objectives: This course covers the emerging topics in the control of power electronics and converters, including the theory behind control, and the practical operation, modeling, and control of basic power system models. This course introduces the most important controller design methods. Discusses the dynamic characterization of terminal behavior for converters, as well as preserving the stability and power quality of modern power systems.

Course Outline: Power electronics converters and converter system, power electronic switches, classification of converters, voltage source converter, basic configuration, multimodule VSC system, multilevel VSC system, DC/AC half bridge converter switched and average model, control of half bridge converter, feed-forward compensation, space phasors and two dimensional frames, two-level, three phase VSC, Three level neutral point clamped VSC, grid imposed frequency VSC system, alpha-beta frame, dq0-frame. Variable and controlled frequency VSC system. Static compensator control system. Dynamic model for PCC voltage control. Three phase current source converter and their control, Parallel operation of the power converters, virtual inertia operation of renewables, low voltage ride through operation of the converters, Phae locked loops and their design, Modeling and control of voltage converter with LCL filters, cyber security in power electronics system, overview of stability analysis methods in power electronics,

Recommended Books:

1. Voltage sourced converter in power system by Reza Iravani and Amirnaser Yazdani.
2. Control of Power Electronic Converters and Systems by Frede Blaabjerg

28. Heating, Ventilation, and Air Conditioning Systems

Course Code: EPS 411
Credit Hrs.: 3+0
Pre-Requisite: Applied Physics

Objectives: This course covers give the knowledge of the vapor compression and vapor absorption refrigeration systems, various refrigerants and their application. The course will also provide the fundamental concepts of air conditioning, its scope and application to perform psychrometric analysis of air conditioning systems.

Course Outline: Introduction and types of cooling systems: Definition and basic terminology. Refrigeration cycle, vapor compression cycle. COP. 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 Air-conditioning: Indoor and outdoor air conditions. Comfort air conditions and comfort zoneindoors air quality, psychrometry, Psychometric chart and psychometric properties, Central air conditioning system ,essential components of central air conditioning plant. 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. Supply fan, air dust cleaning and bacteria removal,air supply and air return terminals. Diffusers, dampers, grillers and registers, Air-conditioning system design: CFM rating and tons of air conditioning of central air conditioning plant,cooling and heating loads. Calculation procedures, duct sizing and piping design, Pumps and fans selection, air ventilation. Calculation of fresh air supply of multi-story buildings, air handling units for treatment of fresh and return,forced convection based air ventilator design. Cooling towers: Types of cooling towers. Performance of cooling tower. Hydronic terminal units. Indoor air quality: Dust and bacteria removal methods.Alternative cooling techniques: Thermo-electric, magnetocaloric,electrocaloric,, Thermo-accoustics, solar-assisted cooling systems

Recommended 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.

29. Business Planning in Energy System

Course Code: MKT 422
Credit Hrs.: 2+0
Pre-Requisite: None

Objectives: The aim is to develop business plans. Students propose projects, define needs and challenges addressed, make critical review of the literature and carry out the market research.

Course Outline:

Investigates management and planning aspects of future energy supplies, Developing integrated policy inteventions to achieve a long-term energy transition: theoretical and empirical perspectives. Energy and climate planning: the role of analytical tools and soft measures. Energy innovation policy: fostering small energy service companies. Competitiveness of distributed generation of heat, power and cooling: System design and policy overview. Are Smart Grids the holy grail? - Economic, environmental and regulatory opportunities for Smart Grid development in North-Western Europe. Renewables optimization in an energy only market. Optimal scheduling of a microgrid under uncertainty condition. Cost Benefit Analysis for Energy Policies. Benchmarking energy efficiency transitions in MENA countries. Energy supply in Europe. Current trends and future perspectives for the natural gas sector. Roller coaster of the Spanish energy policy with the EU.

Recommended Books:

1. Analysis of Energy Systems Management, Planning and Policy by Vincenzo Bianco.
2. Operation, Planning, and Analysis of Energy Storage Systems in Smart Energy Hubs by Behnam Mohammadi-Ivatloo, and Farkhondeh Jabari

30. Production Planning and Control

Course Code: EPS 424
Credit Hrs.: 3+0
Pre-Requisite: None

Objectives: The course enables the students to use various forecasting methods & their applications, different production planning models & capacity requirement planning.

Course Outline:

Forecasting methods and their applications to various industrial and management problems, Analysis and design of production and scheduling control systems, machine sequencing, Flow shop, Job shop, Open shop, Algorithms for production planning and re-planning, Stochastic inventory models, Aggregate planning, Capacity requirements planning, Introduction to mixed production models.

Recommended Books:

1. Operations Management: Sustainability and Supply Chain Management by Heizer, Render and Munson, 12th Edition, 2017.
2. Principle of Production Control by J. L. Burbige, 2nd Edition,1978.
3. Manufacturing Planning & Control by Vollmann, William Berry & Whybark, 4th Edition, 1997.
4. Factory Physics by Hopp & Spearman, 3rd Edition, 2011.

31. Combine Heat and Power System

Course Code: EPS 432
Credit Hrs.: 3+0
Pre-Requisite: Applied Physics

Objectives: The course enables the students to use various forecasting methods & their applications, different production planning models & capacity requirement planning.

Course Outline:

Introduction to conduction, convection and radiation heat transfer, Thermodynamics and heat transfer, Engineering techniques in heat transfer, Different forms of energy, Heat transfer

mechanisms; Conduction Heat transfer, Principles of conductive heat transfer, Energy balances concerning heat transfer, Heat transfer coefficient correlations, Equations of change for isothermal systems, macroscopic balances for isothermal systems, Analytical, approximate solutions to equations of heat transfer, Empirical model for the evaluation of conductive heat transfer coefficients. Principles of convective heat transfer, Shell balances concerning heat transfer, Heat transfer coefficient correlations, Boiling and condensation, transient heat transfer. Equations of change for isothermal systems, macroscopic balances for isothermal systems, Analytical, approximate solutions to equations of heat, transfer, momentum, energy transport, interphase momentum, heat transfer. Empirical model of the evaluation of heat transfer coefficients. Radiation Heat Transfer, Radiation properties, black body radiation, absorptivity, reflectivity, transmissivity, Wien's law, Kirchoff's law, Grey body radiation, Radiation shape factor and relations between shape factors, Heat Exchangers Principles of working of heat exchangers, Thermal design of heat exchangers, Empirical model for the evaluation of heat transfer in heat exchangers An introduction to combined heat and power, the combined heat and power resources, estimating the potential, principles and technologies, piston engine combined heat and power systems, steam turbine combined heat and power system, gas turbine, fuel cell, and nuclear combined heat and power, renewable energy combined heat and power system. The environmental implication of combined heat and power, the economics of combined heat and power.

Recommended Books:

1. Combined Heat and Power by Paul Breeze.
2. Heat Transfer by J. P. Holman, 10th Edition

Fundamentals of Heat and Mass Transfer by Incropera & Dewitt, 7th Edition