Ahsanullah University of Science and Technology (AUST)
Bangladesh

Outcome-Based Education (OBE) Curriculum for Bachelor of Science in Electrical and Electronic Engineering

Approved by UGC

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Part A: Program Specific Information

1. Title of the Academic Programme: B.Sc. in Electrical and Electronic Engineering

2. Name of the University: Ahsanullah University of Science and Technology

3. Vision of the University:

The Ahsanullah University of Science and Technology was established with the aim to be a premier center of excellence in science, engineering, technology and business by creating and transferring knowledge with human values to the young generations in such a way that they, in turn, could enhance the quality of life in Bangladesh and beyond.

4. Mission of the University:

In order to achieve its vision, Ahsanullah University of Science and Technology is engaged in developing human resources in the fields of science, engineering, technology and business to meet the ever changing needs of the society in the perspective of the highly complex and globalized world. The curricula of the university are designed to produce quality graduates imbued with the spirit of ethical values and equipped with knowledge and skills appropriate to their professional fields. AUST graduates are taught and trained to accept the challenges in their arena of jobs and to contribute meaningfully to the society and overall development of the country.

5. Name of the Degree: B. Sc. in Electrical and Electronic Engineering

6. Name of the Faculty offering the program: Faculty of Engineering

7. Name of the Department offering the program: Electrical and Electronic Engineering (EEE)

8. Vision of the Program:

To provide environment for development of skillful graduates and quality research for national and international needs.

9. Mission of the Program:

Missions	Statement
M1	To provide undergraduate education of highest quality
M2	Educate students in research, scholarship and innovation
M3	Build partnership with the industry by meeting the ever changing need of the market through educational, technical, and entrepreneurial activities

10. Description of the Program:

The Department of Electrical and Electronic Engineering of Ahsanullah University of Science and Technology (AUST) is offering a four-year undergraduate degree program since the establishment of AUST in the year 1995. The degree program is spread over eight semesters with two semesters per academic year. The present intake of the students per calendar year is 350 students in seven sections, each of 50 students. The class size has been limited to 50 students in the interest of effective teaching. There are now about 1400 students studying in the department with 63 full time faculty members. Thirty-six batches of students have graduated and are employed in different technical organizations in home and abroad.

The department has already developed its own laboratories in areas such as Electrical Circuits, Electronics, Digital Electronics, Electrical Machines, Telecommunications, Control Systems, Switchgear and Protection, Power Systems, Microwave Engineering, Microprocessors, VLSI Design with Cadence and Digital Signal Processing. The department favors interaction between University and industry and, in this connection, some of the activities of the department are: Education tour of students to industry, power stations and telecommunication centers etc., Seminars: Resource persons are invited to speak on selected topics of interest, Project display of final year students, Job Fair: Prospective employers are invited to speak on job opportunities in their organizations etc.

11. Program Educational Objectives (PEOs):

PEO1 - Professionalism
Graduates will demonstrate sound professionalism in engineering or related fields.

PEO2 – Continuous Personal Development
Graduates will engage in life-long learning in multi-disciplinary fields for industrial and academic careers.

PEO3 – Sustainable Development
Graduates will promote sustainable development at local and international levels.

12. Program Learning Outcomes (PLO):

PO1 - Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO2 - Problem analysis: Identify, formulate, research and analyze complex engineering problems and reach substantiated conclusions using the principles of mathematics, the natural sciences and the engineering sciences.
PO3 - Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety as well as cultural, societal and environmental concerns.
PO4 – Investigation: Conduct investigations of complex problems, considering design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.

PO5 - Modern tool usage: Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to Range of Complex Engineering Activities with an understanding of the limitations.
PO6 - The engineer and society: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
PO7 - Environment and sustainability: Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate the knowledge of, and need for sustainable development.
PO8 – Ethics: Apply ethical principles and commit to professional ethics, responsibilities and the norms of engineering practice.
PO9 - Individual work and teamwork: Function effectively as an individual and as a member or leader of diverse teams as well as in multidisciplinary settings.
PO10 – Communication: Communicate effectively about Range of Complex Engineering Activities with the engineering community and with society at large. Be able to comprehend and write effective reports, design documentation, make effective presentations and give and receive clear instructions.
PO11 - Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work as a member or a leader of a team to manage projects in multidisciplinary environments.
PO12 - Life-long learning: Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the broadest context of technological change.

13. Generic Skills/Graduate Profile (based on Need Assessment)

PO1 - Engineering knowledge
PO2 - Problem analysis
PO3 - Design/development of solutions
PO4 – Investigation
PO5 - Modern tool usage
PO6 - The engineer and society
PO7 - Environment and sustainability
PO8 – Ethics
PO9 - Individual work and teamwork
PO10 – Communication
PO11 - Project management and finance
PO12 - Life-long learning

14. Mapping/Alignment Program's Mission vs PEO

	PEO1	PEO2	PEO3
M1	√		√
M2	√	√	√
M3	√	√	√

15. Mapping/Alignment PEO vs PLO

	PEO1	PEO2	PEO3
PO1 - Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.	√		
PO2 - Problem analysis: Identify, formulate, research and analyze complex engineering problems and reach substantiated conclusions using the principles of mathematics, the natural sciences and the engineering sciences.	√		
PO3 - Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety as well as cultural, societal and environmental concerns.	√		
PO4 – Investigation: Conduct investigations of complex problems, considering design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.	√		
PO5 - Modern tool usage: Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to Range of Complex Engineering Activities with an understanding of the limitations.	√		
PO6 - The engineer and society: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.	√		√
PO7 - Environment and sustainability: Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate the knowledge of, and need for sustainable development.	√		√
PO8 – Ethics: Apply ethical principles and commit to professional ethics, responsibilities and the norms of engineering practice.	√		
PO9 - Individual work and teamwork: Function effectively as an individual and as a member or leader of diverse teams as well as in multidisciplinary settings.	√	√	
PO10 – Communication: Communicate effectively about Range of Complex Engineering Activities with the engineering community and with society at large. Be able to comprehend and write effective	√		

reports, design documentation, make effective presentations and give and receive clear instructions.			
PO11 - Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work as a member or a leader of a team to manage projects in multidisciplinary environments.	√		
PO12 - Life-long learning: Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the broadest context of technological change.		√	

Part B: Course-related Information

16. Curriculum Structure

- **a. Duration of the program: 4 Years/8 Semesters**
- **b. Total minimum credit requirements: 160.5**
- **c. Course Distribution**
  - **i. General Courses (53 credits, 33.02%)**
    - **1. Arts and Humanities (9.5 credits, 5.92%)**
    - **2. Social Sciences (12 credits, 7.48%)**
    - **3. ICT (1.5 credit, 0.93%)**
    - **4. Basic Sciences (30 credits, 18.69%)**
  - **ii. Core Courses (82.5 credits, 51.40%)**
    - **1. Major-Departmental (76.5 credits, 47.66%)**
    - **2. Minor- Non departmental (6 credits, 3.74%)**
  - **iii. Optional/Elective Courses- (18 credits, 11.21%)**
    - **1. Major (N/A)**
    - **2. Minor (N/A)**
  - **iv. Capstone Course/Internship/Thesis/Projects: (7 credits, 4.36%)**

17. Semester/Term/Year/Level wise Courses

Table-1

Year	Semester	Total Credits in syllabus
1	1	21
1	2	19.5
2	1	20
2	2	21
3	1	19.5
3	2	19.5
4	1	19.5
4	2	20.5
Total		**160.5**

a. First Semester/Term/Year/Level courses

Year-1 Semester-1

Course No.	Course Title	Credit
EEE 1101	Electrical Circuits I	3.0
EEE 1102	Electrical Circuits I Lab.	1.5
EEE 1109	Programming Language	3.0
EEE 1110	Programming Language Lab.	1.5

PHY 1105	Physics I	3.0
PHY 1106	Physics I Lab.	1.5
MATH 1103	Mathematics I	3.0
CHEM 1107	Chemistry	3.0
CHEM 1108	Chemistry Lab.	1.5
	Total	**21.0**

b. Second Semester/Term/Year/Level courses

Year-1 Semester-2

Course No.	Course Title	Credit
EEE 1201	Electrical Circuits II	3.0
EEE 1202	Electrical Circuits II Lab.	1.5
EEE 1203	Electronics I	3.0
EEE 1204	Electronics I Lab.	1.5
PHY 1205	Physics II	3.0
MATH 1203	Mathematics II	3.0
CE 1252	Engineering Drawing with CAD	1.5
MATH 1213	Mathematics III	3.0
	Total	**19.5**

c. Third Semester/Term/Year/Level courses

Year-2 Semester-1

Course No.	Course Title	Credit
EEE 2103	Digital Circuit Design	3.0
EEE 2104	Digital Circuit Design Lab.	1.5
EEE 2105	Electrical Machineries	3.0
EEE 2106	Electrical Machineries Lab.	1.5
ME 2151	Mechanical Engineering Fundamentals	3.0
ME 2152	Mechanical Engineering Fundamentals Lab.	1.5
MATH 2103	Mathematics IV	3.0
HUM 2109	Technical English	2.0
HUM 2110	Technical English Lab.	1.5
	Total	**20.0**

d. Fourth Semester/Term/Year/Level courses

Year-2 Semester-2

Course No.	Course Title	Credit
EEE 2203	Electronics II	3.0
EEE 2204	Electronics II Lab	1.5
EEE 2213	Electrical Properties of Materials	3.0
EEE 2200	Electrical Installations	1.5
EEE 2210	Electronic Circuits and Systems Simulation Lab.	1.5
EEE 2226	Numerical Methods for Engineering Lab.	1.5
HUM 2201	Bengali Language and Literature	3.0
MATH 2203	Mathematics V	3.0
HUM 2209	Accounting and Economics	3.0

	Total	**21.0**

e. Fifth Semester/Term/Year/Level courses

Year-3 Semester-1

Course No.	Course Title	Credit
EEE 3105	Power Systems	3.0
EEE 3106	Power Systems Lab.	1.5
EEE 3107	Signals and Linear Systems	3.0
EEE 3109	Microcontroller and Microprocessor	3.0
EEE 3110	Microcontroller and Microprocessor Lab.	1.5
EEE 3100	Fundamentals of Electrical Design	1.5
EEE 3117	Engineering Electromagnetics	3.0
IPE 3159	Industrial Management	3.0
	Total	**19.5**

f. Sixth Semester/Term/Year/Level courses

Year-3 Semester-2

Course No.	Course Title	Credit
EEE 3203	Solid State Devices	3.0
EEE 3207	Communication Engineering	3.0
EEE 3208	Communication Engineering Lab.	1.5
HUM 3229	Society, Ethics and Engineering Laws	3.0
EEE 3211	Electrical and Electronics Instrumentation	3.0
EEE 3212	Electrical and Electronics Instrumentation Lab.	1.5
EEE 3217	Digital Signal Processing	3.0

EEE 3218	Digital Signal Processing Lab.	1.5
	Total	**19.5**

g. Seventh Semester/Term/Year/Level courses

Year-4 Semester-1

Course No.	Course Title	Credit
EEE 4000	Senior Design Project	3.0
EEE 4105	Control System I	3.0
EEE 4106	Control System I Lab.	1.5
EEE 4107	Advanced Communication Systems	3.0
EEE 4108	Advanced Communication Systems Lab.	1.5
EEE ****	Elective	3.0
EEE ****	Elective Lab.	1.5
EEE ****	Elective	3.0
	Total	**19.5**

h. Eighth Semester/Term/Year/Level courses

Year-4 Semester-2

Course No.	Course Title	Credit
EEE 4000	Senior Design Project	3.0
EEE 4202	Seminar	1.0
EEE ****	Elective	3.0
EEE ****	Elective	3.0

EEE ****	Elective Lab.	1.5
EEE ****	Elective	3.0
HUM 4201	History of the Emergence of Independent Bangladesh	3.0
BUS 4257	Entrepreneurship Development for Engineers	3.0
	Total	**20.5**

List of Elective Courses:

i. Power and control group

Sl. No.	Course Code	Course Name	Credit Hour
1	EEE 4531	Electromechanical Devices	3.0
2	EEE 4532	Electromechanical Devices Lab.	1.5
3	EEE 4511	Power System Analysis	3.0
4	EEE 4512	Power System Analysis Lab.	1.5
5	EEE 4551	Power Plant Engineering	3.0
6	EEE 4513	High Voltage Engineering	3.0
7	EEE 4514	High Voltage Engineering Lab.	1.5
8	EEE 4571	Power System Protection	3.0
9	EEE 4572	Power System Protection Lab.	1.5
10	EEE 4591	PLC	3.0

11	EEE 4592	PLC Lab.	1.5
12	EEE 4515	Power System Operation and Control	3.0
13	EEE 4533	Power Electronics and Drives	3.0
14	EEE 4534	Power Electronics and Drives Lab.	1.5
15	EEE 4593	Control System II	3.0
16	EEE 4553	Renewable Energy and Smart Grid	3.0
17	EEE 4555	Nuclear Power Engineering	3.0
18	EEE 4543	Special Electrical Machines	3.0

ii. Electronics and Computers group:

Sl. No.	Course Code	Course Name	Credit Hour
1	EEE 4311	Processing and Fabrication Technology	3.0
2	EEE 4331	VLSI I	3.0
3	EEE 4332	VLSI I Lab.	1.5
4	EEE 4333	Analog Integrated Circuit	3.0
5	EEE 4335	VLSI II	3.0
6	EEE 4336	VLSI II Lab.	1.5
7	EEE 4313	Optoelectronics	3.0
8	EEE 4314	Optoelectronics Lab.	1.5
9	EEE 4391	Microcontroller Based Embedded Systems	3.0

10	EEE 4392	Microcontroller Based Embedded Systems Lab.	1.5
11	EEE 4371	Introduction to Biomedical Engineering	3.0
12	EEE 4372	Introduction to Biomedical Engineering Lab.	1.5
13	EEE 4351	Nano Electronics	3.0
14	CSE 4393	Computer Architecture	3.0
15	EEE 4345	Semiconductor Devices	3.0
16	EEE 4317	Introduction to MEMS Devices	3.0
17	EEE 4395	Robotics	3.0
18	EEE 4396	Robotics Lab.	1.5

iii. Communication and Signal Processing group:

Sl. No.	Course Code	Course Name	Credit Hour
1	EEE 4715	Advanced Digital Signal Processing	3.0
2	EEE 4733	Microwave Engineering	3.0
3	EEE 4734	Microwave Engineering Lab.	1.5
4	EEE 4735	Optical Fiber Communication	3.0
5	EEE 4736	Optical Fiber Communication Lab.	1.5
6	EEE 4719	Random Signals and Processes	3.0
7	EEE 4725	Digital Communication Systems	3.0
8	EEE 4726	Digital Communication Systems Lab.	1.5

Sl. No.	Course Code	Course Name	Credit Hour
9	EEE 4729	Wireless Communications	3.0
10	EEE 4727	Satellite Communication Engineering	3.0
11	EEE 4728	Satellite Communication Engineering Lab.	1.5
12	EEE 4711	Biomedical Signal Processing	3.0
13	EEE 4712	Biomedical Signal Processing Lab.	1.5
14	EEE 4713	Speech and Image Processing	3.0
15	EEE 4714	Speech and Image Processing Lab.	1.5
16	CSE 4723	Data Communication Networks	3.0
17	CSE 4724	Data Communication Networks Lab.	1.5
18	EEE 4717	Multimedia Communications	3.0
19	EEE 4731	Antenna and Wireless Propagation	3.0
20	EEE 4732	Antenna and Wireless Propagation Lab.	1.5

Part C: Course Outlines

DETAILED OUTLINE OF UNDERGRADUATE COURSES FOR EEE PROGRAM

CORE COURSES

YEAR-1, SEMESTER-1

EEE 1101 3 hours per week, 3 Cr.
Electrical Circuits I Prerequisite: Nil

Introduction to electrical circuit variables and elements: Voltage, current, power, energy, independent and dependent sources, resistance. Basic laws of electrical circuits: Ohm's law, Kirchhoff's Current Law (KCL) and Kirchhoff's Voltage Law (KVL). Simple resistive circuits: series and parallel circuits, voltage and current division, source transformation, Wye-Delta transformation. Techniques of network analysis: nodal and mesh analysis including super node and super mesh. Network theorems: Thevenin's, Norton's and superposition theorems and applications. Maximum power transfer condition and reciprocity theorem. Energy storage elements: inductors and capacitors, their characteristics, series-parallel combination of inductors and capacitors. Responses of RL and RC circuits: Natural and step responses. Magnetic quantities and variables: flux, permeability and reluctance, magnetic field strength, magnetic potential, flux density, magnetization curve. Laws in magnetic circuits: Ohm's law and Ampere's circuital law. Series, parallel and series-parallel magnetic circuits.

SUGGESTED TEXT AND REFERENCE BOOKS

- J. Nilsson and S. Riedel, Electric Circuits, 10th ed. Upper Saddle River, NJ: Prentice-Hall, 2009.
- C. R. Paul, Fundamentals of Electric Circuit Analysis, 1st ed. Hoboken, NJ: Wiley & Sons, 2001.

EEE 1102 3 hours per week, 1.5 Cr.
Electrical Circuits I Lab

Laboratory experiments based on theory and concepts learnt in EEE 1101.

SUGGESTED TEXT AND REFERENCE BOOKS

- EEE 1102 Lab Manual.

EEE 1109 3 hours per week, 3 Cr.
Programming Language Prerequisite: Nil

Introduction to digital computers, Programming languages, algorithms and flow charts. Programming using C++: Information representation: Data types: Variables and constants, memory allocation, operators. Control Statements. Functions and program structures. Arrays with Sorting and searching arrays: Bubble sort algorithm, selection sort algorithm, insertion sort algorithm and binary search algorithm. Pointers and References. C++ Strings. Introduction to

Class and Objects. More on classes: constructors, destructors, friend Functions, operator overloading, Inheritance, Polymorphism etc. Data file operations.

SUGGESTED TEXT AND REFERENCE BOOKS

- J. R. Hubbard, *Schaum's Outline of Programming with C++*, 2nd ed. New York, NY: McGraw-Hill, 2000.
- B. Stroustrup, *The C++ Programming Language,* 4th ed. New York, NY: Pearson Education, 2013.
- H. M. Deitel, P. J. Deitel, *C++ How to Program*, 4th ed. Upper Saddle River, NJ: Prentice Hall, 2002.
- H. Schildt, *Teach Yourself C++.* New York, NY: McGraw-Hill, 1994.
- H. Schildt, *Advanced Programming in C.* New York, NY: McGraw-Hill, 1986.

EEE 1110 3 hours per week, 1.5 Cr.
Programming Language Lab

Laboratory experiments based on theory and concepts learnt in EEE 1109.

SUGGESTED TEXT AND REFERENCE BOOKS

- J. R. Hubbard, Schaum's Outline of Programming with C++, 2nd ed. New York, NY: McGraw-Hill, 2000.
- EEE 1110 Lab Manual.
- D. Ravichandran, Programming with C++. New York, NY: McGraw Hill, 2011.
- E. Balagurusamy, Object Oriented Programming with C++, 4th ed. New Delhi, India: Tata Mc-Graw Hill, 2008.

PHY 1105 3 hours per week, 3 Cr.
Physics I Prerequisite: Nil

Waves and Oscillations: Simple harmonic motion, Differential equation of Simple harmonic oscillator, total energy and average energy, combination of simple harmonic oscillations, spring-mass system, torsional pendulum; two body oscillations, reduced mass, damped oscillation, forced oscillation. resonance, vibrations of membranes and columns, progressive wave, power and intensity of wave, stationary wave, energy calculation of progressive and stationary wave, group and phase velocities, sound Waves-Doppler effect, Sabine's formula, architectural acoustics. Ultrasonic wave productions (piezoelectric and magnetoresistance method) and detection: Acoustic grating.
Optics: Theories of light, Huygens' principle, interference of light: Young's double slit experiment, displacement of fringes, and its uses, Fresnel bi-prism, interference in thin film, Newton's ring, interferometers, Diffraction: Diffraction by single slit, diffraction from a circular aperture, resolving power of optical instruments, diffraction by double slit and N-slits, diffraction grating, Polarization: production and analysis of polarized light, Brewster's law, Malus' law, polarization by double refraction, Nicol prism, optical activity, polarimeters,

Defect of images: Spherical aberration, astigmatism, coma, distortion, curvature, chromatic aberration, Optics of crystal effect in crystal, nonlinear optics.

Thermal Physics: Heat and work, Entropy, Laws and theories of thermodynamics and related applications, thermometer, thermocouple, kinetic theory of gases, kinetic interpretation of temperature, specific heats of ideal gases, equipartition of energy, mean free path, work done by gas, isothermal and adiabatic relations, Maxwell's distribution of molecular speeds, reversible and irreversible processes, thermodynamics functions, Maxwell relations, Clausius and Clapeyron equation, Black body radiation.

SUGGESTED TEXT AND REFERENCE BOOKS

- D. Halliday et. al., Physics, 4th ed. Hoboken, NJ: John Wiley & Sons, 1991.
- D. Halliday et. al., Fundamental of Physics, 6th ed. New Delhi, India: Wiley India, 2006.
- G. Ahmed, Physics for Engineers. Dhaka, Bangladesh: Hafiz Book Center, 2005.
- T. Hossain, Waves & Oscillations, 2nd ed. Dhaka, Bangladeh: Rainbow Book Mall, 2008.
- N. Subrahmanyam and B. Lal, Waves & Oscillations, 2nd ed. Noida, UP, India: Vikas Publishing House, 1977.
- B. Lal and N. Subrahmanyam, A Text Book of Optics, 22nd ed. Kolkata, WB, India: S. Chand Publishing, 1995.
- Ghatak, Optics. New Delhi, India: Tata McGraw Hill, 2005.
- Lal, N. Subrahmanyam, Heat and thermodynamics, 16th ed. Kolkata, WB, India: S. Chand Publishing, 2001.
- T. Hossain, A Text Book of Heat, 2nd ed. New Delhi, India: Variety Books, 1975.

PHY 1106 3 hours per week, 1.5 Cr.
Physics I Lab

Laboratory experiments based on theory and concepts learnt in PHY 1105.

SUGGESTED TEXT AND REFERENCE BOOKS

- G. Ahmed and M. Shahabuddin, Practical Physics, 4th ed. Dhaka, Bangladesh: Hafiz Book Centre, 2010.
- R. Resnick and D. Halliday, Physics-I & II. Hoboken, NJ: Wiley & Sons, 1967.
- R. K. Shukla and A. Srivastava, Practical Physics. New Delhi, India: New Age International, 2007.

MATH 1103 3 hours per week, 3 Cr.
Mathematics I Prerequisite: Nil

Differential Calculus:

Limits, Continuity and Differentiability. Successive differentiation of various types of functions. Leibnitz's theorem, Rolle's theorem, Mean value theorem, Taylor's theorem and Maclaurine's theorems in finite and infinite forms, Lagrange's form of remainders. Cauchy's form of remainders, expansion of functions, evaluations of indeterminate forms of L'Hospital's rule. Partial differentiation. Euler's theorem. Tangent and normal. Sub tangent and sub normal in Cartesian and polar co-ordinates. Determination of maximum and minimum values of functions. Curvature, Asymptotes, Curve tracing. Calculus-based proof for purely resistive circuits: Some application on electrical circuit analysis.

Integral Calculus:
Definition, Integration by the method of substitution, Integration by parts, standard integrals. Integration by successive reduction, Introduction of Definite integral, properties of Definite Integral, use in summing series. Walli's formulae, Improper Integrals, Beta and Gamma function, Area under a plane curve and area of a region enclosed by two curves in Cartesian and Polar Co-ordinates, Tarpezoidal rule and Simpson's rule. Volume and surface areas of solids revolution.

SUGGESTED TEXT AND REFERENCE BOOKS

- J. Steward, Calculus, 8th ed. Boston, MA: Cengage Learning, 2016.
- H. Anton et. al., Calculus, 8th ed. Ontario, Canada: Wiley & Sons Canada, 2005.
- M. A. Matin and B. Chakroborty, Differential Calculus, 5th ed. Dhaka, Bangladesh: Standard Publication, 2015.
- M. A. Matin and B. Chakroborty, Integral Calculus, 5th ed. Dhaka, Bangladesh: Standard Publication, 2015.

CHEM 1107 3 hours per week, 3 Cr.
Chemistry Prerequisite: Nil

Atomic Structure: quantum numbers, Pauli's exclusion principle, electronics configuration, periodic table; Balmer series, Lyman series, IR spectra, functional group identification. properties and uses of noble gases; Different types of chemical bonds and their properties, (Metallic, covalent, ionic, secondary, Van Der waals, mixed), Molecular Orbital theory (MOT), Valence band theory (VBT), Valence shell electron pair repulsion (VSPER) theory, Hybridization, resonance. Molecular structure of compounds, selective organic reactions, Comparison among atom, molecule subatomic particle and nanoparticles. Different types of solutions and their compositions; Phase rule; phase diagram of monocomponent system; properties of dilute solutions,
Thermochemistry; chemical kinetics, chemical equilibrium, Ionization of water and pH component) Electrical properties of solutions.
Electrochemistry: conducitivtiy, electrolysis, electrochemical cells, (structure and operating principles of rechargeable battery, Led and Li battery, fuel cells,
Environmental chemistry (Greenhouse effect and CFC, Arsenic pollution, corrosion and control, lightening and its chemical effect on environment) Use of IR spectra to detect elements, Biotechnology.

SUGGESTED TEXT AND REFERENCE BOOKS

- A. Bahl et. al., Essentials of Physical Chemistry, 24th ed. Kolkata, WB, India: S. Chand Publishing, 2000.
- S. Z. Haider, Introduction to Modern Inorganic Chemistry, 3rd ed. London, UK: Edexcel Publishers, 2008.
- S. Glasstone, An Introduction to Electrochemistry. New Delhi, India: East-West Press, 1942.
- A. K. De, Environmental Chemistry, 3rd ed. New Delhi, India: Wiley Eastern, 1994.
- D. L. Pavia, Introduction of Spectroscopy. New York, NY: Saunders College Publishing, 1979.
- B. S. Bahl and A. Bahl, A Textbook of Organic Chemistry, 22nd ed. Kolkata, WB, India: S. Chand Publishing, 2016.

- M. G. Fontana, Corrosion Engineering, 3rd ed. Chennai, India: McGraw Hill India, 2005.
- D. D. Ebbing and S. D. Gammon, General Chemistry, 5th ed. New Delhi, India: AITS Pub, 1998.
- R. D. Madan, Modern Inorganic Chemistry. New Delhi, India: S. Chand Publishing, 1987.

CHEM 1108 3 hours per week, 1.5 Cr.
Chemistry Lab

Laboratory experiments based on theory and concepts learnt in CHEM 1107.

SUGGESTED TEXT AND REFERENCE BOOKS

- Chemistry Laboratory Manual I
- J. Mendham, Vogel's Text Book of Quantitative Chemical Analysis, 6th ed. New Delhi, India: Pearson, 2009.
- Bahl et. al., Essentials of Physical Chemistry, 24th ed. Kolkata, WB, India: S. Chand Publishing, 2000

YEAR-1, SEMESTER-2

EEE 1201 3 hours per week, 3 Cr.
Electrical Circuits II Prerequisite: EEE 1101

Basics of AC: instantaneous current, voltage, power, effective current and voltage, average power, Phasor and complex quantities, impedance, real and reactive power, power factor. Concept of Phasor in AC circuit. Complex power calculations and maximum power transfer. Analysis of single phase AC circuits: series and parallel RL, RC and RLC circuits, Resonance in AC circuits, series and parallel resonance. Q of a circuit, nodal and mesh analysis, application of network theorems in AC circuits. Circuits with non-sinusoidal excitations, transients in AC circuits, passive filters. Magnetically couple circuits. Three-phase circuits: balanced & unbalanced three-phase system, Analysis of the Wye-Wye, Wye-Delta combinations. Power calculations in three-phase circuits. Mutual inductance: circuit analysis considering mutually coupled inductor. Ideal and practical transformer. Natural and step responses of RLC circuits: series and parallel RLC circuit. The forms of the natural response of RLC circuit.

SUGGESTED TEXT AND REFERENCE BOOKS

- J. Nilsson and S. Riedel, Electric Circuits, 10th ed. Upper Saddle River, NJ: Prentice-Hall, 2009.
- R. L. Boylestad, Introductory Circuit Analysis, 11th ed. Upper Saddle River, NJ: Prentice Hall, 2007.

EEE 1202 3 hours per week, 1.5 Cr.
Electrical Circuits II Lab Prerequisite: EEE 1102

Laboratory experiments based on theory and concepts learnt in EEE 1201.

SUGGESTED TEXT AND REFERENCE BOOKS

- R. M. Kerchner and G. F. Corcoran, Alternating Current Circuits, 4th ed. New York, NY: Wiley, 1960.
- C. K. Alexander and M. N. O. Sadiku, Fundamentals of Electric Circuits, 5th ed. New Delhi, India: Tata McGraw Hill, 2010.
- D. R. Patrick and S. W. Fardo, Understanding AC circuits. Woburn, MA: Butterworth-Heinemann, 2000.
- C. Rawlins, Basic AC Circuits, 2nd ed. Amsterdam, Netherlands: Elsevier, 2010.

EEE 1203 3 hours per week, 3 Cr.
Electronics I Prerequisite: Nil

P-N Junction as a Circuit Element: Intrinsic and extrinsic semiconductors, operational principle of p-n junction diode, contact potential, biasing of diode, current-voltage characteristics of a diode, Load line and Q-point, simplified DC and AC diode models, static resistance, dynamic resistance. Photo diodes and LED circuits. Diode Circuits: Half wave and full wave rectifiers, rectifiers with filter capacitor, clamping and clipping circuits. Characteristics of a Zener diode, Zener shunt regulator. Bipolar Junction Transistor (BJT): Current components, BJT characteristics and regions of operation, BJT as an amplifier, biasing the BJT for discrete circuits, load line and Q-point, small signal equivalent circuit models (π, T, re, hybrid model), BJT as a switch. BJT Amplifier Circuits: Voltage and current gain, input output impedance of common base, common emitter and common collector amplifier circuits, multistage amplifiers. Frequency response of BJT. Junction Field-Effect-Transistor (JFET): Introduction, Structure and physical operation of JFET, characteristics, pinch-off voltage, load line and Q-point. Metal Oxide Semiconductor Field Effect Transistor (MOSFET): Introduction, Structure and physical operation of enhancement and depletion type MOSFET, threshold voltage, body effect, current-voltage characteristics of enhancement and depletion type MOSFET, biasing of MOSFET, load line and Q-point. Single–stage MOS amplifiers, MOSFET as a switch.

SUGGESTED TEXT AND REFERENCE BOOKS

- R. L. Boylestad, Electronic Devices and Circuit Theory, 10th ed. New York, NY: Pearson, 2009.
- Sedra and K. C. Smith, Microelectronics Circuits, 5th ed. New York, NY: Oxford University Press, 2008.

EEE 1204 3 hours per week, 1.5 Cr.
Electronics I Lab Prerequisite: Nil

Laboratory experiments based on theory and concepts learnt in EEE 1203.

SUGGESTED TEXT AND REFERENCE BOOKS

- Lab manual of EEE 1203.

PHY 1205 3 hours per week, 3 Cr.

Physics II Prerequisite: Nil

Atomic Structure: Rutherford scattering, Bohr model, Thomson model, Rutherford model, Zeeman effect.
Structure of Matter: Classification of solids, crystal structure of solids, Miller Indices, Atomic packing factor, distinction between metal, insulator and semiconductor, Bragg's law, X-ray Diffraction.
Modern Physics: Galilean relativity and Einstein special theory of relativity, Lorentz transformation equations, Length contraction, time dilation and mass energy relation, Light cone of an event, Photoelectric effect, Compton effect, Concept of Black Hole, De 'Broglie matter waves. Wave particle duality, Heisenberg Uncertainty principle.
Nuclear Physics: Constituents of atomic nucleus, Nuclear binding energy, different types of radioactivity, radioactive decay law, Nuclear reactions, nuclear fission, nuclear fusion Elementary particles (Quarks, Hedron, Meson, Lepton etc), CERN large Hadron Collider.
Mechanics: Kepler's law of planetary motion, the law of Universal Gravitation, the motion of planets and satellites.
Introductory Quantum Mechanics: Wave function, uncertainty principle, postulates, Schrodinger time independent equation, expectation value, probability, Hamiltonian, Case studies, particle in a zero potential, calculation of energy, tunnel effect.
Statistical mechanics: Maxwell Boltzmann distribution, Bose Einstein distribution, Fermi Dirac distribution Experimental techniques; TEM, AFM, STM, Laser based spectroscopy.

SUGGESTED TEXT AND REFERENCE BOOKS

- Beiser, Concepts of Modern Physics, 6th ed. New York, NY: McGraw-Hill, 2003.
- H. Young and R. Freedman, University Physics with Modern Physics, 13th ed. Boston, MA: Addison-Wesley, 2012.
- D. J. Griffiths, Introduction to Quantum Mechanics, 2nd ed. Upper Saddle River, NJ: Prentice Hall, 2005.
- D. Halliday, R. Resnick and J. Walker, Fundamentals of Physics, 10th ed. Hoboken, NJ: Wiley, 2014.
- L. Theraja, Modern Physics, 16th ed. Kolkata, WB, India: S. Chand, 2008.
- Kittel, Introduction to Solid State Physics, 8th ed. Hoboken, NJ: John Wiley & Sons, 2005.

MATH 1203 3 hours per week, 3 Cr.
Mathematics II Prerequisite: Nil

Ordinary Differential Equations:
Degree and order of ordinary differential equations, formation of differential equations by various methods, solution of first order differential equations. Solution of general linear equations of second and higher orders with constant coefficients, applications. Solution of homogeneous linear equations of the higher order when the dependent variables are absent. Solution of differential equations by the method based on the factorization of the operators. Frobenious method. Legendre and Bessel's function. Applications of ODE in transient analysis of electrical circuits.

Partial Differential equations:
Introduction. Linear and non-linear first order equations. Standard forms. Linear equations of higher order. Equations of the second order with variable coefficients. Wave equations. Particular solution with boundary and initial conditions. Electrical circuit based problem analysis.

SUGGESTED TEXT AND REFERENCE BOOKS

- S. L. Ross, Differential Equations, 3rd ed. New York, NY: Wiley, 1984.
- M. M. K. Chowdhury, Differential Equations with Applications. Dhaka, Bangladesh: DA Printing, 2014.
- H. K. Dass, Advanced Engineering Mathematics. New Delhi, India: S. Chand, 1988.
- B. D. Sharma, Differential Equations. New Delhi, India: Kedar Nath Ram Nath, 1979.

MATH 1213 3 hours per week, 3 Cr.
Mathematics III Prerequisite: Nil

Complex Variable:
Complex number system, General functions of a complex variable, Limits and continuity of a function of complex variable and related theorems, Complex differentiation and the Cauchy-Riemann equations, Mapping by elementary functions, Infinite series, Convergence and uniform convergence, Line integral of a complex function, Cauchy's integral formula, Liouville's theorem, Taylor's and Laurent's theorem, Singular points, Residue, Cauchy's residue theorem, Contour integration, Conformal mapping.

Vector Analysis:
Different Coordinate Systems (Polar, Cylindrical, Spherical Coordinates) Coordinate Systems in Two and Three Dimensions. Scalars and vectors, equality of vectors, addition and subtraction of vectors, geometrical interpretation, Multiple product of vectors, Linear dependence and independence of vectors, Differentiation and Integration of vectors together with elementary applications, Line, Surface and volume integrals, Gradient of a scalar functions, divergence and curl of a vector function, various formulae, Integrals form of gradient, divergence and curl, Divergence theorem, Stokes' theorem, Green's theorem and Gauss's theorem. Application of different theorems on applied electromagnetics.

SUGGESTED TEXT AND REFERENCE BOOKS

- S. M. Alex et. al., Engineering Mathematics. New Delhi, India: Dorling Kindersley, 2008.
- H. K. Dass, Advanced Engineering Mathematics. New Delhi, India: S. Chand, 1988.
- M. F. Rahman, Complex analysis. Dhaka, Bangladesh: Titas Publications, 2008.
- D. Spellman et. al., Schaum's Outline of Complex Variables, 2nd ed. New York, NY: McGraw Hill, 2009.
- S. Lipschutz et. al., Schaum's Outline of Vector Analysis, 2nd ed. New Delhi, India: Tata McGraw Hill, 1959.

CE 1252 3 hours per week, 1.5 Cr.
Engineering Drawing with CAD Prerequisite: Nil

Introduction: lettering, numbering and heading; Instrument and their use; sectional views and isometric views of solid geometrical figures. Plan, elevation and section of multistoried building; building services drawings; detailed drawing of lattice towers.

SUGGESTED TEXT AND REFERENCE BOOKS

- As per suggestions of concerned faculty members.

YEAR-2, SEMESTER-1

EEE 2103 3 hours per week, 3 Cr.
Digital Circuit Design Prerequisite: Nil

Analysis and synthesis of Digital Logic Circuits:
Number system and codes, Boolean algebra, De Morgan's law, Logic gates and truth tables, combinational logic design, minimization techniques, Implementation of basic logic gates in CMOS and BiCMOS, Arithmetic and data handling logic circuits, Decoders and encoders, multiplexers, combinational circuit design and Verilog coding Programmable Logic Devices: Logic arrays, Field Programmable logic arrays, Programmable Read-Only Memory

Sequential circuits:
Different types of latches, flip-flops and their design using ASM approach, Timing analysis and power optimization of sequential circuits, Modular sequential logic design: shift registers, counters and their applications TTL:TTL NAND gate operation, current-sourcing and current-sinking action, totem pole output circuit, TTL NOR gate, standard TTL characteristics, supply voltage and temperature range, voltage levels, power dissipation, propagation delay, fan out, introduction to improved TTL series, TTL loading and fan out, other TTL characteristics, connecting TTL outputs together, open collector output, Tri-state, TTL driving CMOS, problem with TTL.

ECL: Basic ECL circuit, ECL OR/NOR gate, ECL characteristics, fan out, speed of operation.

SUGGESTED TEXT AND REFERENCE BOOKS

- M. M. Mano, *Digital logic and Computer Design,* 1st ed. New Jersey: Prentice Hall, 1979.
- J. P. Hayes, *Computer Architecture and Organization,* 3rd ed. New York: McGraw Hill, 1998.

EEE 2104 3 hours per week, 1.5 Cr.
Digital Circuit Design Lab Prerequisite: Nil

Laboratory experiments based on theory and concepts learnt in EEE 2103. Design of simple systems using the principles learned in EEE 2103.

SUGGESTED TEXT AND REFERENCE BOOKS

- M. M. Mano and M. Ciletti, *Digital Design: With an Introduction to the Verilog HDL, VHDL, and SystemVerilog*, 6th ed. London, England: Pearson, 2017.

EEE 2105 3 hours per week, 3 Cr.
Electrical Machineries Prerequisite: EEE 1101, EEE 1201

Fundamentals of Electrical Machines: Principles, types, construction, windings DC Machines: DC generator: construction, emf and torque induced in a rotating loop under a magnetic field, internal generated voltage and induced torque of a real dc machine. DC Motor: production of back emf, equivalent circuit of a separately excited dc motor, derivation of output characteristics of a dc motor. Methods of speed control. Transformer: Introduction, Functions of transformer, working principle, Ideal transformer, equivalent circuit of an ideal and practical transformer, voltage regulation, losses, efficiency, tests, three phase transformer construction, Auto transformer, parallel operation of 3-phase transformer, Vector group of 3-phase transformer. Synchronous Generator: Construction and basic principle of operation, different types of excitation, equivalent circuit, armature reaction, phasor diagram of a synchronous generator with resistive, inductive and capacitive loads, the effect of load changes on a generator operating alone, voltage regulation, Advantages and conditions for parallel operation of generators. Synchronous Motor: Basic principle of operation, effect of field current changes on a synchronous motor, V-curves, power factor correction. Induction Motor: Principle of operation, Rotating magnetic field, construction, Equivalent circuit, torque speed characteristics, efficiency, and speed control of 3-phase induction motor.

SUGGESTED TEXT AND REFERENCE BOOKS

- S. J. Chapman, *Electric Machinery Fundamentals*, 5th ed. New York: McGraw-Hill Education, 2011.
- B.L. Thereja and A. K. Thereja, *A Text Book of Electrical Technology - Volume II: AC & DC Machines*, 23rd ed. New Delhi, India: S. Chand, 2006.
- V.k. Mehta and R. Mehta, *Principles of Electrical Machines*, New Delhi, India: S. Chand, 2006.
- C. I. Hubert, *Electric Machines- Theory, Operation, Application, Adjustment and Control*, 2nd ed. New Delhi, India: Pearson, 2002.
- Z. A. Yamayee and J. L. Bala, *Electromechanical Energy Devices and Power System*,1st ed. New Jersey: Wiley, 1993.
- F. Puchstein *et al.*, *Alternating-Current Machines*, 3rd ed. New Jersey: Wiley, 1964.
- E. Fitzgerald, *Electric Machinery*, 6th ed., New York: McGraw Hill, 2005.

EEE 2106 3 hours per week, 1.5 Cr.
Electrical Machineries Lab Prerequisite: Nil

Laboratory experiments based on theory and concepts learnt in EEE 2105. Design of simple systems using the principles learned in EEE 2105.

SUGGESTED TEXT AND REFERENCE BOOKS

- EEE 2106 Lab Manual

- S. J. Chapman, *Electric Machinery Fundamentals*, 5th ed. New York: McGraw-Hill Education, 2011.
- B.L. Thereja and A. K. Thereja, *A Text Book of Electrical Technology - Volume II: AC & DC Machines*, 23rd ed. New Delhi, India: S. Chand, 2006.

HUM 2109 2 hours per week, 2 Cr.
Technical English Prerequisite: Nil

General Discussion: Introduction, various approaches of learning English. Grammatical Problems: Construction of sentences, grammatical errors, sentence variety and style, conditionals, vocabulary and diction. History of electricity. Nikola Tesla, the man who lit up the world. Technical texts. Multiword lexical units. How to read an English technical text? Six principles of technical writing. Abstract writing guidelines.
Laboratory Work: Reading Skill: -To understand a wide variety of texts including diagrams, tables, graphs, course brochures and job advertisements. - To compare different sources of information, written and spoken. Writing Skill: -To write simple descriptions and explanations on technical subjects related to student's field of study. - To write study- and work-related letters. General Strategies for Writing Process: Generating ideas, identifying audiences and purposes, construction arguments, stating problems, drafting and finalizing.
Approaches to Communication: Communication today, business communication, different types of business communication. Listening Skill: Understand native speakers, professionals and students talking about their work and study. Understand experts talking informally about technical aspects. Speaking Skill: Communications on technical topics; practicing dialogue; Effective oral presentation. Report Writing: Defining a report, classification of reports, structure of a report, writing of reports.

SUGGESTED TEXT AND REFERENCE BOOKS

- Liz and J. Soars,New, *New Headway Intermediate (student's Book)*, Oxford, England: Oxford Univ. Press, 2003.
- Liz and J. Soars, *New Headway Intermediate (Work Book)*, Oxford, England: Oxford Univ. Press, 1996.
- M. Imhoof and H. HudsonFrom, *From Paragraph to Essay*, London, England: Longman, 1975.
- E. L. Tibbitts, *Exercises in Reading Comprehension*, London, England: Longman, 1976.
- L. Sue. Baugh, *How to Write First Class Letters?* New York: McGraw-Hill Education, 1994.
- J. M. Reid, *The Process of Composition*, New Jersey: Prentice Hall, 1988.
- Lesiker and Flatley, *Basic Business Communication*, 7th ed. by Lesiker and Flatley, New York: McGraw-Hill Education, 1995.

HUM 2110 3 hours per week, 1.5 Cr.
Technical English Lab Prerequisite: Nil

Reading Skill: To understand a wide variety of texts including diagrams, tables, graphs, course brochures and job advertisements. - To compare different sources of information, written and spoken. Writing Skill: -To write simple descriptions and explanations on technical subjects related to student's field of study. - To write

study- and work-related letters. General Strategies for Writing Process: Generating ideas, identifying audiences and purposes, construction arguments, stating problems, drafting and finalizing.
Approaches to Communication: Communication today, business communication, different types of business communication. Listening Skill: Understand native speakers, professionals and students talking about their work and study. Understand experts talking informally about technical aspects. Speaking Skill: Communications on technical topics; practicing dialogue; Effective oral presentation. Report Writing: Defining a report, classification of reports, structure of a report, writing of reports.

SUGGESTED TEXT AND REFERENCE BOOKS

- *English Lab Manual for Listening and Reading*
- M. Imhoof and H. HudsonFrom, *From Paragraph to Essay*, London, England: Longman, 1975.
- E. L. Tibbitts, *Exercises in Reading Comprehension*, London, England: Longman, 1976.
- L. Sue. Baugh, *How to Write First Class Letters*, New York: McGraw-Hill Education, 1994.
- Liz and J. Soars,New, New Headway Intermediate (student's Book), Oxford, England: Oxford Univ. Press, 2003.
- Liz and J. Soars, New Headway Intermediate (Work Book), Oxford, England: Oxford Univ. Press, 1996.

MATH 2103 3 hours per week, 3 Cr.
Mathematics IV Prerequisite: Nil

Linear Algebra:
Introduction to systems of linear equations. Gaussian elimination. Definition of matrices. Transpose of a matrix and inverse of matrix. Factorization, Determinants. Quadratic forms. Matrix polynomials. Euclidean n-space. Linear transformation from R^n to R^m. Properties of Linear transformation from R^n to R^m. Real vector spaces and subspaces. Basis and dimension. Rank and nullity. Inner product spaces. Gram-Schmidt process and QR-decomposition. Eigenvalues and eigenvectors. Diagonalization. Linear transformation. Kernel and Range. Application of linear algebra to electric networks.

Laplace Transformation:
Definition, Laplace transformation of some elementary functions. Sufficient conditions for existence of Laplace transformation. Inverse Laplace transforms. Laplace transforms of derivatives. Some special theorems on Laplace transforms. Partial fraction. Solution of differential equations by Laplace transforms. Evaluation of improper integrals. Application of Laplace transformation to electric networks.

SUGGESTED TEXT AND REFERENCE BOOKS

- Rahamn, *Linear Algebra*
- H. K. Das, *Advanced Engineering Mathematics*, 19th revised ed. New Delhi, India: S. Chand, 2008.
- M. R. Spiegel, *Laplace transform,* 1st ed. New York: McGraw-Hill Education, 1965.
- C. Mandal, *Linear Algebra,* Dhaka, Bangladesh: Nadi Publications, 2014.

- S. Lipschutz and M. Lipson, *Linear Algebra*, 6th ed. New York: McGraw-Hill Education, 2017.

ME 2151 3 hours per week, 3 Cr.
Mechanical Engineering Fundamentals Prerequisite: Nil

Introduction to source of energy: Steam generating units with accessories and mountings; steam turbines, condenser, vapour cycles.
Internal combustion engine: Introduction to internal combustion engines and their cycles, gas turbines.
Refrigeration and air conditioning: Applications, refrigerants, different refrigeration methods.
Fluid Machinery: Fluid Flow, measurement of flow, friction in flow, centrifugal pumps, fans, blowers, and compressor.
Fundamental of conduction, convection and radiation: One dimensional steady state conduction in plated pipes, critical thickness of insulation.

SUGGESTED TEXT AND REFERENCE BOOKS

- R.S. Khurmi and J. Gupta, *A Textbook of Thermal Engineering*, 1st ed. New Delhi, India: S. Chand, 2006.
- R.S. Khurmi and J. Gupta, *A Textbook of Refrigeration and Air Conditioning*, 1st ed. New Delhi, India: S. Chand, 2006.
- Y. A. Cengel and J. H. Cimbala, *Fluid Mechanics Fundamentals and Applications*, 3rd ed. New York: McGraw-Hill Education, 2013.
- F. M. White, *Fluid Mechanics*, 7th ed. New York: McGraw-Hill Education, 2011.
- H. N. Gupta, *Fundamentals of Internal Combustion Engines*, 2nd ed. New Delhi, India: PHI, 2013.

ME 2152 3 hours per week, 1.5 Cr.
Mechanical Engineering Fundamentals Lab Prerequisite: Nil

Sessional works compatible to ME 2151: Mechanical Engineering Fundamentals

SUGGESTED TEXT AND REFERENCE BOOKS

- Lab Manual - http://www.aust.edu/lab_manual.htm
- F. M. White, *Fluid Mechanics*, 7th ed. New York: McGraw-Hill, 2011.
- Y. A. Cengel and J. H. Cimbala, *Fluid Mechanics Fundamentals and Applications*, 3rd ed. New York: McGraw-Hill Education, 2013.
- Y. A. Cengel and M. A. Boles, *Thermodynamics: An Engineering Approach*, 6th ed, Uttar Pradesh, India: Tata McGraw-Hill Education Private Limited, 2008.

YEAR-2, SEMESTER-2

EEE 2203 3 hours per week, 3 Cr.
Electronics II Prerequisite: EEE 1101, EEE 1201, EEE 1203

Feedback Amplifier: Feedback amplifier, Positive feedback, Negative Feedback, Properties, gain bandwidth product, basic topologies, feedback amplifiers with different topologies, Voltage series feedback amplifier, Current series feedback amplifier, Voltage shunt feedback amplifier, Current shunt feedback amplifier, loop gain, stability of feedback circuit, frequency compensation. Power Amplifiers: Classification Power Amplifiers, output stages, Class A, B, AB and C power amplifiers design and output stage, Efficiency calculation, Crossover Distortion, Harmonic distortion, Total harmonic distortion, Total power calculation. Operational Amplifiers (Op-Amp): Properties of ideal and practical OP-Amps, operation modes, open loop operations, non-inverting and inverting amplifiers, inverting integrators, differentiator, weighted summer and other applications of Op-Amp circuits, Electronic Analog computation, Differential Amp, Differential and Common gain, comparator, effects of finite open loop gain and bandwidth on circuit performance, DC imperfections. DC analysis, small-signal analysis of different stages, gain and frequency response of 741 OP-Amp. Active Filters: Different types of filters and specifications, transfer functions, realization and design of first, second and third order low, high, band pass and band reject filters using OP-Amps. Phase Shifter Frequency Response of Amplifiers: Poles, Zeros and Bode plots, amplifier transfer function, techniques of determining 3 dB frequencies of amplifier circuits. Oscillators: Barkhausen principle, Sinusoidal oscillators, Phase shift oscillator, general form of oscillator circuit, Hartley and Colpitts oscillator, Multivibrator, Wein-bridge oscillator, crystal oscillators. VCO, Timer Circuit.

SUGGESTED TEXT AND REFERENCE BOOKS

- J. Millman and A. Grabel, *Microelectronics*, 2nd ed. New York: McGraw-Hill, 1987.
- R. F. Coughlin and F. F. Driscoll, *Operational Amplifiers and Linear Integrated Circuits*, 6th ed. London, England: Pearson, 2001.
- R. Boylestad and L. Nashelksy, *Electronic Devices and Circuit Theory*, 11th ed. London, England: Pearson, 2012.

EEE 2204 3 hours per week, 1.5 Cr.
Electronics II Lab Prerequisite: Nil

Laboratory experiments based on theory and concepts learnt in EEE 2203.

SUGGESTED TEXT AND REFERENCE BOOKS

- EEE 2204-Lab manual
- R. Boylestad and L. Nashelksy, *Electronic Devices and Circuit Theory*, 11th ed. London, England: Pearson, 2012.
- J. Millman and A. Grabel, *Microelectronics*, 2nd ed. New York: McGraw-Hill, 1987.
- S. Sedra and K. C. Smith, *Microelectronic Circuits*, 6th ed. Oxford, England: Oxford University Press, 2011.
- N. N. Bhargava *et al.*, *Basic Electronics and Linear Circuits*, 2nd ed. New Delhi, India: Tata McGraw-Hill, 2013.

- R. F. Coughlin and F. F. Driscoll, *Operational Amplifiers and Linear Integrated Circuits*, 6th ed. London, England: Pearson, 2000.

EEE 2200 3 hours per week, 1.5 Cr.
Electrical Installations Prerequisite: EEE 1101, EEE 1201

Introduction to Electrical installations and regulations:
Symbols and legends used for electrical services design. Definitions of fuses, circuit breakers, distribution boxes, cables, bus-bars, conduits.
Calculation of illumination, total loads. Selection of cables and breakers.
Introduction to building regulations, Regulations in Bangladesh National Building Code.
Design of Wiring system for a building:
Familiarization with computer aided software based drawing tools for electrical wiring diagram, wiring system design and drafting of both low and high rise buildings.
Design of sub-station, bus-bar trunking (BBT), earthlings and lightning protection system of a building. A design problem on a multi-storied building using computer aided software.
Design of paging & security system for a building:
Design intercom, PABX, audio and video paging system, Design of security and protection systems including CCTV, fire detection and alarm system.

SUGGESTED TEXT AND REFERENCE BOOKS

- Electrical Services for Building and Industries - Md. Shah Alam Talukder. PEng.
- Bangladesh National Building Codes [BNBC]
- Building Construction Act of Bangladesh 1952, amended in 2008.
- IEE Regulations - IEE U.K. British Standard - B.S.
- R.P. Ward, *Introduction to Electrical Engineering*, 2nd ed. New Jersey: Prentice Hall, 1952.
- R. Shutterworth, *Mechanical and Electrical system for Construction*, New York: McGraw-Hill, 1983.
- F. S. Merrit, *Building Engineering and system design*, New York: Van Nostrand Reinhold Company, 1979.
- B. L. Thereja, *Text Book of Electrical Technology*, 25th ed. New Delhi, India: S. Chand, 2008.
- Gray, G. A. Wallace, *Principles and Practice of Electrical Engineering*, 6th ed. New York: McGraw-Hill, 1947.
- J. H. Callender, *Time Saver Standard Architecture: A Handbook of Architectural Design*, New York: McGraw-Hill, 1966.

EEE 2210 3 hours per week, 1.5 Cr.
Electronic Circuits and Systems Simulation Lab Prerequisite: Nil

Designing of Electronic Circuits and Systems using CAD tools (Simulink, Proteus, LabVIEW, Quartus etc.)

SUGGESTED TEXT AND REFERENCE BOOKS

- EEE 2210 Lab Manual

- R. L. Boylestad, L. Nashelsky, *Electronic Devices and Circuit Theory*, 10th ed. New Jersey: Prentice Hall, 2008.
- F. F. Driscoll and R. F. Coughlin, *Operational Amplifiers and Linear Integrated Circuits*, 6th ed. London, England: Pearson, 2000.

EEE 2226 3 hours per week, 1.5 Cr.
Numerical Methods for Engineering Lab Prerequisite: Nil

Laboratory on numerical techniques using computer solution of differentiation and integration problems, transcendental equations, linear and non-linear differential equations and partial differential equations.

SUGGESTED TEXT AND REFERENCE BOOKS

- Lab Manual of EEE 2226
- A Beginner's Guide to MATLAB, Christos Xenophontos (online edition)
- R. Pratap, *Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers*, 1st ed. Lucknow, India: OUP India, 2010.
- S. Chapra and R. Canale, *Numerical Methods for Engineers*, 6th ed. New York: McGraw-Hill, 2009.

HUM 2201 3 hours per week, 3 Cr.
Bengali Language and Literature Prerequisite: Nil

প্রথমপাঠ- ভাষা
১। বাংলা ধ্বনি/ বাগধ্বনি (Phone/Speech Sound), বর্ণ (Letter), অক্ষর (Syllable) ২। বাংলা ধ্বনির উচ্চারণ স্থান ও রীতি (Point of Articulation and Manner of Articulation) ৩। বাংলা উচ্চারণ- প্রমিত (Standard), আঞ্চলিক (Dialectal), বৈচিত্র (Variation) ৪। অপিনিহিতি, অভিশ্রুতি, স্বরসঙ্গতি, শ্বাসাঘাত (Stress accent), স্বরভঙ্গি / স্বরতরঙ্গ (Intonation) ৫। বাংলা ও ইংরেজির তুলনা ৬। বাংলা লিখন দক্ষতা- সাধু / চলিত রীতি, বিরামচিহ্ন প্রয়োগ, প্রমিত বাংলা বানানের নিয়ম (বাংলা একাডেমী) ৭। ব্যবহারিক বাংলাঃ (সংক্ষিপ্ত আলোচনা) ২১ শে ফেব্রয়ারী, মুক্তিযুদ্ধ, বাংলা ভাষা, বিশ্বায়ন, বাংলার উৎসব, ষড়ঋতু, বাংলা নববর্ষ, আধুনিক তথ্য-প্রযুক্তি, বাংলার লোকসংস্কৃতি, মানবতা ও নৈতিকতা

দ্বিতীয়পাঠ- সাহিত্য
কবিতাঃ ১। আবদুল হাকিম- নূরনামা ২। মাইকেল মধুসূদন দত্ত- বঙ্গভাষা ৩। লালনসাঁই- খাঁচার ভেতর অচিন পাখি ৪। রবীন্দ্রনাথ ঠাকুর- নির্ঝরের স্বপ্নভঙ্গ ৫। কাজী নজরল ইসলাম- আজ সৃষ্টি সুখের উল্লাসে ৬। জীবনানন্দ দাশ- রূপসী বাংলা ৭। হাসান হাফিজুর রহমান- অমর একুশে ৮। আলাউদ্দিন আল আজাদ- স্মৃতি স্তম্ভ ৯। শামসুর রাহমান- তোমাকে পাওয়ার জন্য হে স্বাধীনতা ১০। সৈয়দ শামসুল হক- পরিচয়
প্রবন্ধঃ ১।বঙ্কিম চন্দ্র চট্টোপাধ্যায়- বাঙ্গালা ভাষা ২। রবীন্দ্রনাথ ঠাকুর- সভ্যতার সংকট ৩। হর প্রসাদ শাস্ত্রী- তৈল ৪। প্রমথ চৌধুরী- যৌবনে দাও রাজটিকা ৫। কাজী নজরল ইসলাম- বর্তমান বিশ্ব সাহিত্য ৬। মুহাম্মদ আবদুল হাই- আমাদের বাংলা উচ্চারণ ৭। কবীর চৌধুরী- আমাদের আত্মপরিচয়
ছোটগল্প ও অনন্য রচনাঃ ১। রবীন্দ্রনাথ ঠাকুর- পোস্ট মাস্টার ২। রোকেয়া সাখাওয়াত হোসেন- অবরোধ বাসিনী ৩। বিভূতিভূষণ বন্দোপাধ্যায়- পুঁইমাচা ৪।

সৈয়দ ওয়ালিউল্লাহ- নয়নচারা ৫। জাহানারা ইমাম- একাত্তরের দিনগুলি ৬। হাসান আজিজুল হক- ঘরগেরস্থি ৭। আখতারুজ্জামান ইলিয়াস- অপঘাত
নাটকঃ ১। মুনির চৌধুরী- কবর

SUGGESTED TEXT AND REFERENCE BOOKS

- বাংলা ভাষা ও সাহিত্য – রফিকুল ইসলাম ও সৌমিত্র শেখর
- ভাষাবিজ্ঞানের ভূমিকা ও বাংলা ভাষা – সৌরভ সিকদার
- পাঠ্য বইয়ের বানান – আনিসুজ্জামান (সম্পা)
- Dil, *Bengali Language and Culture*, Dhaka, Bangladesh: Adorn Publications, 2014.

MATH 2203 3 hours per week, 3 Cr.
Mathematics V Prerequisite: Nil

Fourier Analysis:
Frequency domain analysis of Linear Time Invariant (LTI) systems: Fourier series- properties, harmonic representation, Real and complex forms, Finite Fourier transforms, Fourier integral, Fourier transforms and their uses in solving boundary value problems. Introduction to Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT)

Probability and Statistics:
Introduction, Frequency distribution, Mean, median, mode. Standard deviation, moments, skewness and kurtosis, Sets and Probability, Random variable and its probability distributions, Treatment of grouped sampled data, Some discrete probability distributions, Dependent and independent events, Multiplication rules, Bayes Theorem, Normal distribution, Binomial, poison and negative binomial, Sampling theory, Estimation theory, Tests of hypotheses, Regression and correlation, Correlation: Ideas of correlation, Measurement of correlation, Pearsonian correlation coefficient, Spearman's rank correlation coefficient, Analysis of variance.

SUGGESTED TEXT AND REFERENCE BOOKS

- R. Walpole *et al., Probability and Statistics for Engineers and Scientists*, 9th ed. London, England: Pearson, 2016.
- H. K. Das, *Advanced Engineering Mathematics*, 19th revised ed. New Delhi, India: S. Chand, 2008.
- R. Walpole *et al., Probability and Statistics for Engineers and Scientists*, 9th ed. London, England: Pearson, 2016.
- S. M. Ross, *Introduction to Probability and Statistics for Engineers and Scientists*, 4th ed. Cambridge: Academic Press, 2009.
- S. P. Gupta, M. P. Gupta, *Business Statistics*, 14th ed. New Delhi, India: S. Chand, 2007.
- G. James *et al*., *Advanced Modern Engineering Mathematics*, 3rd ed. London, England: Pearson, 2003.
- S. M. Alex, B. Z. Hussain, D. J. Prabhakaran, *Engineering Mathematics*, New Delhi, India: Dorling Kindersley, 2008.

HUM 2209 3 hours per week, 3 Cr.
Accounting and Economics Prerequisite: Nil

Accounting : Definition, Activities of Accounting, Objectives of Accounting Information, Users of accounting information, Qualitative characteristics of accounting information, GAAP, Basic Assumptions, Basic Principles, Basic Accounting Equation and Its Components, Introduction to transaction, Features of transaction, Transaction Vs. Event, Identification of transaction and Transaction analysis, Financial statements, The Account, Debits and Credits, Summary of Debit/Credit Rules, The Journal, Preparation of Journal, The Ledger, Posting in the ledger Trial Balance, Objective of Trial balance, Preparation of Trial Balance and Limitations of trial balance, Financial Statements from trial balance, Managerial and cost accounting, Cost Concepts and Cost Classification, Preparation of Schedule of Cost of Goods Manufactured and Income Statement, Cost-Volume-Profit (CVP) Analysis, Contribution margin, Safety margin, Target performance and Using CVP for decision making.

Economics: Definition of Economics; Economics and engineering; Principles of economics, Macro-economics: Savings; investment, employment; national income analysis; Inflation; Monetary policy; Fiscal policy and trade policy with reference to Bangladesh; Micro-Economics: Introduction to various economic systems – capitalist, command and mixed economy; Fundamental economic problems and the mechanism through which these problems are solved; Theory of demand and supply and their elasticities; Theory of consumer behavior; Cardinal and ordinal approaches of utility analysis; Price determination; Nature of an economic theory; Applicability of economic theories to the problems of developing countries; Indifference curve techniques; Theory of production, production function, types of productivity; Rational region of production of an engineering firm; Concepts of market and market structure; Cost analysis and cost function; Small scale production and large scale production; Optimization; Theory of distribution; Use of derivative in economics: maximization and minimization of economic functions, relationship among total, marginal and average concepts.

SUGGESTED TEXT AND REFERENCE BOOKS

- P. Samuelson & W. Nordhaus, *Economics*, 19th ed. New York: McGraw Hill, 2009.
- J. J. Weygandt, Kieso *et al*., *Accounting Principle*, 12th ed. New Jersey: Wiley, 2015.
- R. Garrison, *Managerial Accounting*, 13th ed. New York: McGraw-Hill, 2009.
- E. D. Dowling, *Introduction to Mathematical Economics*, 3rd ed. New York: McGraw-Hill, 2000.
- M. L. Jhingan, *Theory of Development and Planning*, 40e ed. New Delhi, India: Vrinda Publications (P) Ltd., 2014.
- K. K. Dewett, *Modern Economic Theory*, New Delhi, India: S. Chand, 2006.

EEE 2213 3 hours per week, 3 Cr.
Electrical Properties of Materials Prerequisite: Nil

Crystal structures: Types of crystals, lattice and basis, Bravais lattice and Miller indices, APF), Concept of Reciprocal lattice, Brillouin zone. Quantum mechanics: Wave nature of electrons, Schrodinger's equation, Hamiltonian, 1D and 3D potential well problems, tunnel effect, Solution of Schrodinger equation for Hydrogen atom, Silicon, Carbon. Band theory of solids: Band theory from molecular orbital, Bloch theorem, Kronig-Penny model, effective mass, density-

of-states. Classical theory of electrical and thermal conduction: Drude model, Scattering, mobility and resistivity, temperature dependence of metal resistivity, Mathiessen's rule, Hall Effect and thermal conductivity, applications. Modern theory of metals: Brief review on Statistical mechanics, Determination of Fermi energy and average energy of electrons, Seeback effect, Thermocouple, Mott and Jones Equation. Semiconductor properties of materials: Intrinsic, Extrinsic semiconductor, hole, compensation doping, space charge neutrality, Valance band and Conduction band function, Fermi level, Degenerate semiconductor, Direct and Indirect semiconductor. Drift, mobility, scattering, Hall effect, High field effect, Gunn effect. Diffusion coefficient and current equation. Dielectric properties of materials: Dielectric constant, polarization- electronic, ionic and orientational; internal field, Clausius-Mosotti equation, spontaneous polarization, frequency dependence of dielectric constant, dielectric loss and piezoelectricity, ferroelectricity, pyroelectricity, applications. Magnetic properties of materials: Magnetic moment, magnetization and relative permittivity, different types of magnetic materials, origin of ferromagnetism and magnetic domains, soft and hard magnetic materials, applications of magnetic materials. Magnetic resonance, Introduction to superconductivity: Zero resistance and Meissner effect, Type I and Type II superconductors and critical current density, Josephson Effect, High temperature superconductors, applications of superconductors. Introduction to nanomaterial: Quantized Hall effect. (Quantized Hall effect, nanostructure, thin films, CNTs, zigzag, armchair, applications). plasmonic materials: Liquid crystals, Composite materials, Polymers (PVC, TEFLON, etc.), Metamaterial. PWR-BWR-FBTR) AFM, Laser based spectroscopy.

SUGGESTED TEXT AND REFERENCE BOOKS

- S. O. Kasap, *Principles of Electronic Materials and Devices*, 4th ed. New York: McGraw-Hill, 2017.
- D. A. Neamen, *Semiconductor Physics and Devices*, 3rd ed. New Delhi, India: Tata McGraw-Hill, 2003.
- A. J. Dekker, *Electrical Engineering Materials*, New Delhi: Prentice-Hall, 1991.
- A. Beiser, *Perspectives of Modern Physics*, New Delhi: India: McGraw-Hill Book Company, 1969.
- B. Streetman, S. Banerjee, *Solid State Electronic Devices*, New Delhi, India: PHL Learning, 2006.

YEAR-3, SEMESTER-1

EEE 3105 3 hours per week, 3 Cr.
Power Systems Prerequisite: EEE 1101, EEE 1201, EEE 2105

System Modeling: Equivalent model of synchronous machine and transformer, per-unit computations and advantages, one-line diagram. Network parameters: Inductance and capacitance of power transmission line, GMD, GMR, resistance, skin effect, Ferranti effect, Introduction to corona and its effects, equivalent circuit of short, medium and long line; Power factor and voltage control in power system: Tap changing transformer, OFF load and ON load tap changing transformer, regulating transformer, boosting transformer; Distribution system: distributor calculation of radial feeders, ring mains and interconnections; Mechanical characteristics of overhead transmission line: sag and tension analysis, effect of

temperature, wind and ice loading, supports of different levels, dampers, insulators of overhead lines; Underground cables; Introduction to Power System Analysis: Basic techniques of load flow studies.

SUGGESTED TEXT AND REFERENCE BOOKS

- J. J. Grainger and W. D. Stevenson, Jr. *Power System Analysis*, 2nd ed., UK: Mc Graw Hill Education, 2015.
- V. K. Mehta, R. Mehta, *Principles of Power System*, 4th ed., New Delhi: S. Chand & Company Ltd, 2010
- A. Chakrabarti, M. L. Soni, et al., *A Textbook on Power System Engineering*, 2nd ed., Dhanpat Rai & Co. (P) Ltd, 2009
- R. K. Rajput, *A Textbook on Power System Engineering*, latest edition, Laxmi Publications (P) Ltd, 2006
- D. P Kothari, I. J Nagrath, *Modern Power System Analysis*, 4th Edition, Tata McGraw Hill Education (P) Ltd, 2011
- H. Saadat, *Power System Analysis*, 3rd ed., PSA Publishing LLC, 2011

EEE 3106 3 hours per week, 1.5 Cr.
Power Systems Lab Prerequisite: EEE 2106

Laboratory experiments based on theory and concepts learnt in EEE 3105. Design of simple systems using the principles learned in EEE 3105.

SUGGESTED TEXT AND REFERENCE BOOKS

- EEE 3106 Lab Manual
- EEE 2106 Lab Manual

EEE 3107 3 hours per week, 3 Cr.
Signals and Linear Systems Prerequisite: EEE 1201, MATH 2103, MATH 2203

Introduction to signal and systems; Signals- classification, basic operation, elementary signals, representation of signal using impulse function; Systems: classification.
Properties of Linear Time Invariant (LTI) systems: linearity, causality, time invariance, and other properties.
Time domain analysis of LTI systems: differential equations-system representation, order of the system, solution techniques, zero state and zero input response.
System properties: impulse response, convolution integral, determination of system properties.
State variables: basic concept, static equation and time domain solution.
Frequency domain analysis of LTI systems: Fourier series and properties, harmonic representation, system response, frequency response of LTI systems.
Fourier transformation: properties, system transfer function, system response, distortion less systems, and representation of aperiodic signals. Applications of time and frequency domain analysis.

Laplace Transformation: Properties, inverse transform, solution of system equations, system transfer function, system stability and frequency response and application.
Analysis of Analogous Systems: Electrical, mechanical and electro-mechanical systems.

SUGGESTED TEXT AND REFERENCE BOOKS

- S. S. Soliman and M. D. Srinath, *Continuous and Discrete Signals and Systems*, 2nd ed., Pearson, 1998.
- V. Oppenheim, A.S. Willsky et al., *Signals and Systems*, 2nd ed., India: Pearson, 2015
- L. Phillips, J. Parr et al., *Signals, Systems, & Transforms*, 5th ed., Pearson, 2013
- P. Lathi, *Linear Systems and Signals,* 2nd ed., Oxford University Press, 2004
- *K. Cheng, Signals and Linear Systems*

EEE 3109 3 hours per week, 3 Cr.
Microcontroller and Microprocessor Prerequisite: EEE 1109, EEE 1110

Fundamental Concepts: Four basic tasks of a programmable device (the Microcontroller and Microprocessor); Uses of microcontroller; Introduction to the external and internal architectures of a typical (ATmega328) microcontroller (MCU). Types of programming languages (Text Code, Pseudo Code, Flow Chart, Assembly Code, and HLL); Introduction to Microcontroller Learning Kits, Language. Introduction to 8086 Learning Systems;
Overview; Ports as general digital I/O; Alternate port functions; Register descriptions; Applications; Related C functions and methods. Memory: Flash Memory (boot, code, and application sections); EEPROM Data Memory; SRAM Data Memory; Register file; User RAM; Stack space; Programming methods of Code and EEPROM. Fuse bits and Lock bit/security issues. C functions and methods. Analog Port: Various modes of operations: free running, sleep mode, and etc.; resolving cross talk among analog channels; Applications; Timer/Counter: Various modes of operations of TC0, TC1, and TC2; Generating various timing functions like time delay, PWM and etc.; Applications; Interrupt Structure: Meaning of interruption; Interrupt vectors; External hardware interrupts; Pin change interrupts; Applications; Overview; Asynchronous protocol; Port initialization; SPI Port: Overview; SPI protocols; Applications; Two-wire (I2C): TWI protocol; Data transfer and frame format; Applications; Related C functions and methods. Fuse Bits and Lock Bits: Role of fuse bits and lock bits for system configuration and security; programming procedures; applications; Interfacing of Sensors and Peripheral Modules: Passive Temperature and Humidity sensors; Load Cell; Bus operational Temperature/Humidity Sensors; Bus operated Accelerometer/Magnetometer modules; Interfacing of multi-channel serial ADC; System Design: Introduction to Intel Family of Microprocessors

SUGGESTED TEXT AND REFERENCE BOOKS

- Golam Mostafa, *ATmega328P Microcontroller Laboratory Experiments Manual***,** Bangladesh**.**

EEE 3110 3 hours per week, 1.5 Cr.
Microcontroller and Microprocessor Lab Prerequisite: EEE 2103

Laboratory experiments based on theory and concepts learnt in EEE 3109. Design of simple systems using the principles learned in EEE 3109.

SUGGESTED TEXT AND REFERENCE BOOKS

- Golam Mostafa, ATmega*328P Microcontroller Laboratory Experiments Manual using Arduino UNO Learning Kit*.,Bangladesh.
- G. Smith, *Introduction to Arduino: A piece of cake!*, CreateSpace Independent Publishing Platform, 2011.

EEE 3117 3 hours per week, 3 Cr.
Engineering Electromagnetics Prerequisite: PHY 1105

Review of vector calculus, Divergence theorem, Stoke theorem. Electrostatic fields: Coulomb's law, charge distributions, electric field intensity and Divergence, force, principle of superposition; Gauss' Law; Applications of divergence and Stoke's theorem; Maxwell's equations in electrostatic field; Electric scalar potential; Conduction and polarization, current, resistance and capacitance, electrostatic potential energy, method of images, boundary conditions; Laplace and Poisson's equations. Magnetostatic Fields: Magnetic vector potential, magnetic force; Bio-Savart's law; Ampere's Circuital law; Faraday's Law; Inductance; Applications of Divergence and Stoke's Theorem; Maxwell's equations in Magnetostatic field. Boundary conditions; Lorentz force equation. Time varying electromagnetic fields: Plane wave propagation; Transmission lines and equations. Transmission line analogy: normal and oblique incidence of plane waves at plane boundaries for different polarization. Electromotive force, Faraday's Law, Lentz's Law. Continuity equation. Maxwell's equations in time-varying field. Waves equations in source-free region and lossy medium, Poynting vector, Solutions of plane wave equations. Basics of antennas and environmental issues.

SUGGESTED TEXT AND REFERENCE BOOKS

- D. K. Cheng, *Fundamentals of Engineering Electromagnetics*, 1st ed., Pearson, 2019
- M. N. O. Sadiku, *Elements of Electromagnetics*, 7th ed., Oxford University Press, 2018
- W. H. Hayt and J. A. Buck, *Engineering Electromagnetics*, 7th ed., McGraw-Hill, 2009
- F. T. Ulaby, *Electromagnetics for Engineers*, 1st ed., Pearson, 2004

IPE 3159 3 hours per week, 3 Cr.
Industrial Management Prerequisite: Nil

Introduction: Evolution, Management Function, Organization and environment; Operational Management: Production Planning, Types of production systems, Forecasting, ABC Analysis, Inventory Control, Work study; Organization: Theory and structure, Co-ordination, Span of control, Authority delegation, Groups, Committee and task force, Manpower planning; Personnel Management: Scope, Importance, Need hierarchy, Motivation, Job redesign, Leadership, Participative

Management, Training, Performance Appraisal, Wages and incentives, Informal groups, Organizational change and conflict; Cost and Financial Management: Elements of costs of products depreciation, Depreciation, Break even analysis, Investment analysis, Benefit cost analysis; Marketing Management: Concepts, Strategy, Sales promotion, Patent laws; Technology Management: Management of innovation and changes, Technology Life cycle, Case studies.

SUGGESTED TEXT AND REFERENCE BOOKS

- W. J. Stevenson, *Operation Management*, 13th ed., McGraw-Hill Education,2017
- S. P. Robbins and M. Coulter, *Management*, 11th ed., Eleventh Edition, 2011
- E. M. Wicks and W. G. Sullivan, *Engineering Economy*, 15th ed., Pearson College Div, 2010
- P. Kotler, K. Keller, et al., *Marketing Management*, 13th ed., Pearson education, 2018
- T. M. Khalil & R. Shankar, *Management of technology: the key to competitiveness and wealth creation*, 2nd ed., McGraw-Hill Education, 2013

EEE 3100 3 hours per week, 1.5 Cr.
Fundamentals of Electrical Design Prerequisite: Nil

Design of simple circuits for household equipment, power systems control and communication systems using the principles learned throughout the previous semesters.

SUGGESTED TEXT AND REFERENCE BOOKS

- R. Ford, C. Coulston, 'Design for Electrical and Computer Engineers', McGraw Hill, 2008
- C. L. Dym, P. Little, *Engineering Design: A Project-Based Introduction*, 3rd ed., John Wiley, 2008.
- K. P. et al., *Exploring Engineering: An introduction for Freshmen to Engineering and to the Design Process*, Elsevier Inc., 2006.
- G. E. Dieter, *Engineering Design*, 3rd ed., McGraw-Hill, 2000.
- B. Hyman, *Fundamentals of Engineering Design*, 2nd ed., Prentice Hall, 2003.

YEAR-3, SEMESTER-2

EEE 3203 3 hours per week, 3 Cr.
Solid State Devices Prerequisite: EEE 1203, EEE 2213

Introduction: classifications, applications, Fabrication steps Semiconductors: Crystal structure, Electronic model of semiconductors and solids, valance band model, valance band, energy gap, conduction band, Energy bands, energy band diagram of semiconductors, Extrinsic semiconductor, space charge neutrality Carrier statistics, Boltzmann approximation, electron and hole concentrations, mass action law, Fermi Dirac integral, temperature dependence of carrier concentrations and invariance of Fermi level. E-K, E-x, Direct and Indirect semiconductor, heavy hole band etc. Carrier Transport Processes and Excess

Carriers: Diffusion, generation and recombination of excess carriers, built-in-field, Einstein relations, Boltzmann relations, Continuity and diffusion equations for holes and electrons and quasi-Fermi level, Ambipolar transport, diffusion length, Haynes-Shockley experiment, Trapping and Tunneling, Shockley-Read-Hall Recombination, Luminescence processes. PN Junction: structure, equilibrium conditions, contact potential, equilibrium Fermi level, DC electrical characteristics of p-n junction, energy band diagram of a biased p-n junction, Shockley diode equation, charge control switching analysis of p-n junction. Space charge, non-equilibrium condition, forward and reverse bias, carrier injection, minority and majority carrier currents. Metal semiconductor junction, Schottky effect, Metal semiconductor diode, rectifying and ohmic contacts, Band diagram. Field effect transistors. MOS Structure: MOS capacitor, energy band diagrams and flat band voltage, threshold voltage and control of threshold voltage, static C-V characteristics, charge control modes, qualitative theory of MOSFET operation, body effect and current-voltage relationship of a MOSFET, Non-Ideal behavior of device: Short channel Effects, Drain-induced barrier lowering and punch through, Surface scattering, Velocity saturation. MOSFET scaling, hot electron effect. Mobility Model. Junction Field Effect Transistor: Introduction, qualitative theory of operation, pinch off voltage and current-voltage relationship Bipolar Junction Transistor: Basic principles, terminal current equation, coupled-diode model, charge control analysis, Ebers-Moll deviation from ideal behavior. Heterojunction bipolar transistor (HBT), Band gap grading Early effect, High level injection. Nano devices: Carbon Nano Tube (CNT), Graphene Nano Ribbon (GNR), CNTFET, GNRFET. Basic Principle and Applications, Optical devices: Photodiodes, Light-Emitting Diodes. Efficient Energy saving LED, Solar cell Basics Principle and Applications.

SUGGESTED TEXT AND REFERENCE BOOKS

- B.G. Streetman, S.K. Banerjee, *Solid State Electronic Devices*, 6th Edition, Prentice-Hall Int., 2000
- D.A. Neaman, *Semiconductor Physics and Devices*, 3rd Edition, Tata McGraw-Hill, 2003
- S.O. Kasap, *Principles of Electronic Materials and Devices*, 3rd Edition, McGraw-Hill. 2006.
- R.F. Pierret, *Advanced Semiconductor Fundamentals*, 2nd Edition, Prentice-Hall, 2003.
- S.M. Sze, *Physics of Semiconductor Devices*, 2nd Edition, John Wiley & Sons, Inc, 1981
- Beiser, *Concepts of Modern Physics*, 6th Edition, McGraw-Hill
- Michael Shur, *Physics of Semiconductor Devices*, 1st Edition, Prentice-Hall, 1990

EEE 3207 3 hours per week, 3 Cr.
Communication Engineering Prerequisite: Nil

Introduction to communication systems: basic principles, elements of communication systems, mathematical models, types of transmission media, bandwidth requirements and transmission capacity.

Fundamental principles of modulation/demodulation techniques: amplitude modulation (AM)/demodulation, frequency modulation (FM)/demodulation and

phase modulation (PM)/demodulation. Analysis of such systems in the time and frequency domains.

Sampling theorem: Nyquist criterion, aliased free sampling; PAM, PCM-quantization, companding, differential PCM, demodulation of PCM. Delta modulation. Digital Modulation: ASK, FSK, PSK, DPSK, QPSK, their corresponding bandwidth requirements and noise performance; Multiplexing/Demultiplexing techniques: TDM/DEMUX-principles and synchronization systems, FDM/DEMUX. Multiple-access techniques: time-division multiple-access (TDMA), frequency-division multiple access (FDMA), spread spectrum technique, code-division multiple access (CDMA).

Line coding: RZ, NRZ, AMI, Manchester. Introduction to data communication networks. Introduction to OSI and TCP/IP model. Introduction to different communication network (LAN, MAN, WAN). Circuit switching, packet switching. Brief introduction to different communication systems.

SUGGESTED TEXT AND REFERENCE BOOKS

- B. P Lathi and Z. Ding, *Modern Digital and Analog Communication Systems,* 5th ed., New York: Oxford University Press, 2019.
- S. Haykin, *Communication Systems,* 2nd ed., Wiley, 1994
- B. A. Forouzan, *Data Communication and Networking,* 5th ed., McGraw-Hill Education, 2012
- J. C. Bellamy, *Digital Telephony*, 3rd ed., New Delhi: Wiley India, 2006
- V. K Mehta, *Principle of Electronics,* 7th ed., India: Chand (S.) & Co Ltd, 2005

EEE 3208 3 hours per week, 1.5 Cr.
Communication Engineering Lab Prerequisite: Nil

Laboratory experiments based on theory and concepts learnt in EEE 3207. Design of simple systems using the principles learned in EEE 3207.

SUGGESTED TEXT AND REFERENCE BOOKS

- B. P Lathi and Z. Ding, *Modern Digital and Analog Communication Systems*, 5th ed., New York: Oxford University Press, 2019.
- S.S. Haykin and M. Moher, *Communication Systems*, 5th ed., Hoboken, N.J: John Wiley, 2010.

EEE 3211 3 hours per week, 3 Cr.
Electrical and Electronics Instrumentation Prerequisite: Nil

Introduction: Applications, functional elements of a measurement system and classification of instruments, accuracy, calibration.

Measurements: Units and standards. Measurement of resistance, inductance and capacitance. A.C Bridge methods. Localization of cable fault.

Measurement of Electrical Quantities: Current and voltage measurement: Moving coil and moving iron instruments. Electrodynamometer type instrument, power and energy measurement. Power factor measurement. Transformer: Current and potential transformer.
Transducers: Mechanical, Electrical and Optical transducers.
Measurement of Non-Electrical Quantities: Temperature, pressure, flow, level, strain, force and torque, earthquake, speed, frequency, phase difference.
Basic Elements of DC and AC Signal Conditioning: Instrumentation amplifier, noise and source of noise, noise elimination compensation, function generation and linearization, Analog to Digital Converts (A/D), and Digital to Analog Convert (D/A) and their uses in Instrumentation, Digital voltmeter.
Display device: Cathode ray oscilloscope, Digital storage oscilloscope, Spectrum analyzer, Network Analyzer
Data Transmission and Telemetry: Methods of data transmission, telemetry system, RF and landline telemetry and digital data transmission. Data acquisition system and microprocessor, microcontroller applications in instrumentation.

SUGGESTED TEXT AND REFERENCE BOOKS

- K. SAWHNEY, *A Course in Electrical and Electronic Measurements and Instrumentation*, 19th ed., Darya Ganj, New Delhi: Dhanpat Rai & Co., 2016
- R. F. COUGHLIN and F. F. DRISCOLL, *Operational Amplifiers and Linear Integrated Circuits*, 6th ed., Delhi: PHI Learning, 2014.
- A.D. HELFRICK and W.D. COOPER, *Modern Electronic Instrumentation and Measurement Techniques*, Chennai, India: Pearson India Education, 2016
- M.M.S. ANAND, *Electronic Instruments and Instrumentation Technology*, New Delhi: Prentice Hall of India, 2004.

EEE 3212 3 hours per week, 1.5 Cr.
Electrical and Electronics Instrumentation Lab Prerequisite: Nil

Laboratory experiments based on theory and concepts learnt in EEE 3211.

SUGGESTED TEXT AND REFERENCE BOOKS

- EEE 3212 Lab Manual
- R. F. COUGHLIN and F. F. DRISCOLL, Operational Amplifiers and Linear Integrated Circuits, 6th ed., Delhi: PHI Learning, 2014
- K. SAWHNEY, A Course in Electrical and Electronic Measurements and Instrumentation, 19th ed., Darya Ganj, New Delhi: Dhanpat Rai & Co., 2016

EEE 3217 3 hours per week, 3 Cr.
Digital Signal Processing Prerequisite: EEE 3107

Introduction to Digital Signal Processing (DSP): necessity, applications, ideal signals vs. real signals. Analog to digital conversion: sampling and sampling

theorem. Introduction to systems: systems, discrete-time signals, requirements and different properties of linearity. Superposition theorem. Linear Time Invariant (LTI) systems. Impulse response, finite impulse response (FIR) and infinite impulse response (IIR) of discrete time systems. Discrete transformations: advantages of frequency domain analysis, Types of Discrete Fourier Transform: Discrete Fourier series, discrete-time Fourier series, Discrete Fourier Transform (DFT) and properties. Fast Fourier Transform (FFT), Inverse Fast Fourier Transform (IFFT). Z-transformation: properties, transfer function, pole-zero placement method and inverse Z-transform. Correlations. Digital Filters: concept of digital filters. FIR filters: linear phase filters, minimum phase filters, moving average filters. IIR filters: specifications, design using impulse invariant and bi-linear z-transformation method. Application of DSP using digital filters-case study.

SUGGESTED TEXT AND REFERENCE BOOKS

- S. W. Smith, *The Scientist and Engineer's Guide to Digital Signal Processing*, 2nd ed., San Diego, Calif.: California Technical Pub.,1999.
- B. P. Lathi and R. Green, *Essentials of Digital Signal Processing*, New York N.Y. Cambridge University Press, 2014
- K. A. K. Ossman, *Introduction to Digital Signal Processing Theory and Applications Using MATLAB.*
- J.G Proakis and D.G Manolakis, *Digital Signal Processing, Principles, Algorithm, and Applications*, 3rd ed., India: Prentice-Hall, 2000
- Jose Maria Giron Sierra, *Signal Processing with Matlab Examples, Volume 1*, Springer-2018

EEE 3218 3 hours per week, 1.5 Cr.
Digital Signal Processing Lab Prerequisite: EEE 3107

Laboratory experiments based on the theories and concepts taught in Digital Signal Processing (EEE 3217). Analysis of various types of signals using simple signal processing algorithms.

SUGGESTED TEXT AND REFERENCE BOOKS

- Lab Manual of EEE 3218

HUM 3229 3 hours per week, 3 Cr.
Society, Ethics and Engineering Laws Prerequisite: Nil

Understanding of socio-economic structure: agriculture, industry, service sectors, national issues, policies, and politics. Historical perspectives: social, economic, technical, and political. Population, health, and environment. Awareness of the responsibilities of a professional engineer in society: understanding of socio-economic, cultural and professional responsibilities. Principles of ethics: code of ethics, regulations of professional conducts and legal practices. Use of moral reasoning skills to examine, analyze and resolve ethical and legal issues. Truth telling, privacy, confidentiality, fairness vs. biasness. Economic considerations,

exploitation, manipulation. Development of professional knowledge, skills and legal responsibilities as an engineer to the advancement of human welfare. Knowledge of report preparation from engineering and other forms of work-experiences. Awareness of national and international rules and standards with respect to professionalism and research. Legal methodology and legal engineering practice: public laws and private laws. Legal relationship among the government, corporations, individuals, and protection of the individual rights. Company law: Law regarding formation, incorporation, management and winding up of companies; Labor law: Law in relation to wage hours, health, safety and other work conditions; Law of compensation.

SUGGESTED TEXT AND REFERENCE BOOKS

- M. Winston, R. Edelbach, *Society, Ethics and Technology*, 5th ed., Boston, MA: Wadsworth Cengage Learning, 2014
- Gordon C. Andrews, *Canadian Professional Engineering & Geoscience: Practice and Ethics*, 5th ed., Nelson College Indigenous, 2013
- M.C. Kucchal and V. Kucchal, *Mercantile Law*, 8th ed., Vikas, 2018
- N. Dhar, *Labour & Industrial Laws of Bangladesh with hints on Questions and Answers*, 2nd ed.

YEAR-4, SEMESTER-1 (Core)

EEE 4105 3 hours per week, 3 Cr.
Control System I Prerequisite: EEE 3107

Introduction to Control Systems:
Linear system models transfer function, block diagram and Signal Flow Graph (SFG).

State Variables:
SFG to state variables, transfer function to state variable and state variable to transfer function

Feedback Control System:
Open loop vs. Closed loop systems, parameter sensitivity, transient characteristics of control systems, effect of additional pole and zero on the system response and system types and steady state error. Routh's stability criterion.

Analysis of Feedback Control System:
Root locus method and frequency response method.

Design of Feedback Control System:
Controllability and observability, root locus, frequency response and state variable methods. Controller design using frequency response- Nyquist plot, Bode diagram, Nichols plot, Nyquist's stability theorem.

Compensation:
Lead-lag compensators, PID controllers.

SUGGESTED TEXT AND REFERENCE BOOKS

- R. C. Dorf and R. H. Bishop, "Modern control systems". Hoboken, NJ: Pearson Education, Inc., 2022.
- S. M. Shinners, Modern Control System Theory and Application, Reading Mass. (u.a.): Addison-Wesley, 1979.
- J. J. DAzzo and C. H. Houpis, Feedback Control System Analysis & Synthesis, New York: McGraw-Hill Book Company, 1966.
- N. S. Nise, Control systems engineering, Hoboken, NJ: John Wiley & Sons, 2019.

EEE 4106 3 hours per week, 1.5 Cr.
Control System I Lab Prerequisite: N/A

Laboratory experiments based on theory and concepts learnt in EEE 4105.

SUGGESTED TEXT AND REFERENCE BOOKS

- EEE 4106 Lab Manual.

EEE 4000 3 hours per week, 6 Cr.
Senior Design Project Prerequisite: N/A

In this course, students are required to undertake a major project in engineering analysis, design development of research with emphasis on electrical and electronic engineering problems. The objective is to provide an opportunity to develop initiative, self-reliance creativity etc. in the field of electrical and electronic engineering. The results must be submitted in a comprehensive report with appropriate drawings, charts, bibliography, etc. along with products if any. Use of locally available materials in manufacturing and feasibility study of local industrial units will be emphasized.

SUGGESTED TEXT AND REFERENCE BOOKS

- As per suggestions of concerned faculty members.

EEE 4107 3 hours per week, 3 Cr.
Advanced Communication Systems Prerequisite: N/A

Introduction to different advanced communication systems. Advanced digital modulation techniques: DPSK, CPFSK, QPSK, M-PSK, MSK, and GMSK. Adaptive DPCM, adaptive DM. Wireless propagation channel and model: AWGN channel, multipath effect, shadowing, ISI, bit error rate, channel capacity theorem, bandwidth limitations, and power efficiency. Information theory, source coding, Huffman coding; Channel coding: linear block codes, cyclic codes. Pulse shaping techniques, equalizers, LMMSE, adaptive equalizers, matched filters, rake receivers. Advanced multiple-access

techniques: SDMA, WCDMA. Diversity technique/ OFDM/MIMO. Layers of data communication networks. Packet switching and PSTN systems. ISDN, ADSL. Voice over Internet Protocol (VoIP). Cellular concept: basic architecture and operation. 3G~5G Wireless networks.

SUGGESTED TEXT AND REFERENCE BOOKS

- B. P. Lathi and Z. Ding, Modern digital and analog communication systems, 3rd edition. New York: Oxford University Press, 2019.
- B. A. Forouzan and S. C. Fegan, Data communications and networking,4th edition. Boston: McGraw-Hill, 2007.
- J. C. Bellamy, Digital telephony, 4th ed. New York: Wiley, 1982.
- S. S. Haykin, Communication systems, 2nd ed. New York: Wiley, 1994.
- K Mehta, Principles of Electronics, 7th Edition, Chand (S.) & Co Ltd, India; 2005.

EEE 4108 3 hours per week, 1.5 Cr.
Advanced Communication Systems Lab Prerequisite: N/A

Laboratory experiments based on theory and concepts learnt in EEE 4107.

SUGGESTED TEXT AND REFERENCE BOOKS

- EEE 4108 Lab Manual.
- B. P. Lathi and Z. Ding, Modern digital and analog communication systems, 3rd edition. New York: Oxford University Press, 2019.
- B. A. Forouzan and S. C. Fegan, Data communications and networking,4th edition. Boston: McGraw-Hill, 2007.
- J. C. Bellamy, Digital telephony, 4th ed. New York: Wiley, 1982.
- S. S. Haykin, Communication systems, 2nd ed. New York: Wiley, 1994.
- K Mehta, Principles of Electronics, 7th Edition, Chand (S.) & Co Ltd, India; 2005.

YEAR-4, SEMESTER-2 (Core)

HUM 4201 3 hours per week, 3 Cr.
History of the Emergence of Independent Bangladesh Prerequisite: N/A

1. Introduction: Introduction of people and country including Land, Rivers, Hills, Tribes, Religion, Weather & Climate, Regional language etc., Importance of learning history of the emergence of independent Bangladesh
2. Brief Background History: The Mughal Bengal, Bhuyan's Bengal, Siraj-Ud-Daulah & Plassey's battle, British Bengal, Mughal Structure and Architecture etc.
3. Bilingualism, Pakistan state structure and Discrimination: Sectarian politics, Lahore Proposition in 1940, Banga vanga and its causes, Discrimination between east and west Pakistan
4. Language Movement and Trial for Establishing Democratic Government: Different stages in language movement, Establishment of Juktofront in 1954, 21-point commitment of Juktofront election and its results, Juktofront government and its activities.

5. Martial Law of Ayub Khan and Development of Nationalism: Ayub martial law in 1958-1962, Reform activities of Ayub government, Revolution against Ayub, Presidential election of 1965, Resistance against Bengali cultural aggression, 6-point movement of Sheikh Mujibur Rahman, Agartala conspiracy
6. Mass Orchestration of 1969 and 11 Point Movement
7. Election of 1970 and Bangabandhu's Declaration of Independence
8. Liberation War of 1971: 25th March of 1971, Mujibnagar Government, Stages of war, Publicity of liberation war, Role of world superpower, Activities of Shanti committee; Al-badr; Al-shams and Razakar's. Killing of Bengali Intellectuals, Victory Day, 16th December 1971.

SUGGESTED TEXT AND REFERENCE BOOKS

- Muntassir Mamoon, Md. Mahbubur Rahman, History of the Emergence of Independent Bangladesh, University Grants Commission of Bangladesh. Dhaka, December 2017.
- R. Plunkett, A. Newton, B. Wagenhauser, and J. Murray, Lonely Planet guide to Bangladesh. Lonely planet, 2000.

BUS 4257 3 hours per week, 3 Cr.
Entrepreneurship Development for Engineers Prerequisite: N/A

Introduction to Entrepreneurship– Entrepreneurship and Technology endeavours, Engineers as Entrepreneurs, Approach of an Entrepreneur, Creating and Selling the Entrepreneurial Value Proposition.
Idea Generation and Feasibility study – Entrepreneurial Idea Generation and Feasibility Analysis, Technology Commercialization Potential, Paths and obstacles from Idea to Market, Assessing and Presenting the Opportunity, Pre-launch considerations - Legal protection of Intellectual property, Legal form of an organization, Intellectual Property Strategies for Technology Companies.
Planning and Execution – Business Structuring and Strategy, Business Planning and the Business Plan, Financial Analysis and Projections, Market and Competitive Analysis, Market research for entrepreneurs, Marketing, Sales and Distribution Strategies, Designing and organizing a sales force, Growing the organization into a sustainable business.

SUGGESTED TEXT AND REFERENCE BOOKS

- Dorf, Richard, Byers, Thomas, Nelson, Andrew, Technology Ventures: From Idea to Enterprise, 3rd Edition
- G. Kawasaki, The art of the start: the time-tested, battle-hardened guide for anyone starting anything, New York: Portfolio, 2004.
- Timmons, Jeffry A, New Venture Creation, 6th Edition. McGraw-Hill January 2004.

EEE 4000 3 hours per week, 6 Cr.
Senior Design Project Prerequisite: N/A

In this course, students are required to undertake a major project in engineering analysis, design development of research with emphasis on electrical and electronic engineering problems. The objective is to provide an opportunity to develop initiative, self-reliance creativity etc. in the field of electrical and

electronic engineering. The results must be submitted in a comprehensive report with appropriate drawings, charts, bibliography, etc. along with products if any. Use of locally available materials in manufacturing and feasibility study of local industrial units will be emphasized.

SUGGESTED TEXT AND REFERENCE BOOKS

- As per suggestions of concerned faculty members.

EEE 4202 1 hour per week, 1 Cr.
Seminar Prerequisite: N/A

The aim of this course is to inform the students, the method by which a technical matter can be presented using effective communication techniques. Students should be able to understand the different communication type and how to create and deliver a presentation to a targeted audience.

SUGGESTED TEXT AND REFERENCE BOOKS

- David H. Foster, "A Concise Guide to Communication in Science and Engineering", OXFORD university press, 2017.
- M Ahsan Ullah Khan, "Communication That Works", Panjeree Publications Ltd., Bangladesh, 2013.
- MTD Training, Effective Communication Skills, Ventus Publishing, 2012.

ELECTIVE COURSES

YEAR-4, SEMESTER-1/2
Power and Control Group (Elective)

EEE 4531 3 hours per week, 3 Cr.
Electromechanical Devices Prerequisite: EEE 2105

Synchronous Machines: Winding, equation of developed power and torque, power angle characteristics, armature reaction, concept of direct axis and quadrature axis reactance, synchronous impedance, synchronous impedance method of predicting voltage regulation, parallel operation, synchronizing current, hunting and oscillation, cooling, Losses & efficiency, frequency versus real power and terminal voltage versus reactive power characteristics.
Transformer: Inrush current, harmonics, instrument transformer, phase shifting transformer, zigzag transformer, cast resin transformer.
Induction Motor: 3-phase: Reversal of rotating magnetic field, Slip, torque and developed rotor power, effect of changing rotor resistance and reactance on torque speed characteristics, maximum torque and its condition, classification, losses, efficiency, Tests, starting methods, protection system of motor, speed control with VFD, braking, circle diagram.
Single-phase: Theory of operation and starting of single phase induction motor Equivalent circuit, construction and classification, torque speed characteristics. Universal motor.
Induction generator: Operation, characteristics, applications.

SUGGESTED TEXT AND REFERENCE BOOKS

- "Electric Machinery Fundamentals" by Stephen J. Chapman, fourth edition, McGraw Hill
- "Electric Machinery" by A. E. Fitzgerald, Jr., Charles Kingsley, Stephen Umans, sixth edition, McGraw Hill
- "A Text Book of Electrical Technology", Vol-II, by B. L. Thereja and A. K. Thereja - S. Chand and Company.

EEE 4532 3 hours per week, 1.5 Cr.
Electromechanical Devices Lab Prerequisite: N/A

Laboratory experiments based on theory and concepts learnt in EEE 4531.

SUGGESTED TEXT AND REFERENCE BOOKS

- Stephen J. Chamman, Electric Machinery Fundamentals, McGraw-Hill International Edition.
- V. K. Mehta and R. Mehta, Principles of electrical machines: for degree, AMIE, diploma & other engineering examinations. New Delhi: S. Chand & Co., 2007.
- E. Fitzgerald, C. Kingsley, S. D. Umans, Electrical Machinery, Tata McGraw-Hill.
- L. Thereja, A. K. Thereja, A Text Book of Electrical Technology, Vol-II, S. Chand and Company.

EEE 4511 3 hours per week, 3 Cr.
Power System Analysis Prerequisite: EEE 3105

System Modeling & Load flow studies: Power network representation, per unit system of calculations, Bus admittance & bus impedance matrices, Network reduction, Load flow studies using the Gauss-Seidel and Newton-Raphson methods. Fault Analysis: Balanced three phase faults- Synchronous generator reactance, Fault level calculation. Unbalanced faults- Symmetrical components, Sequence models, Fault calculation using Thevenin's method and ZBUS. Power system stability: Definition and classification of power system stability, Frequency and voltage stability, Rotor angle stability, swing equation, Equal area criterion, Solution of swing equation, Methods of improving stability. Introduction to FACTS: Controllable parameters in power flow, Classification of FACTS- Shunt compensation (SVC, STATCOM), Series compensation (SSSC, TCSC) and Series-shunt compensation (UPFC). Power Quality: Voltage sag and swell, Surges, Harmonics, Flicker, Grounding problems, IEEE/IEC standards, mitigation techniques.

SUGGESTED TEXT AND REFERENCE BOOKS

- W. D. Stevenson, Elements of power system analysis, 4th ed. New Delhi: McGraw Hill Education (India), 2015.
- D. P. Kothari and I. J. Nagrath, Power system engineering. New Delhi: Tata McGraw-Hill, 2009.
- C. A. Gross, Power system analysis. New York: John Wiley & Sons, Inc. wen jing, 1986.

EEE 4512 3 hours per week, 1.5 Cr.
Power System Analysis Lab Prerequisite: EEE 2106

Laboratory experiments based on theory and concepts learnt in EEE 4511.

SUGGESTED TEXT AND REFERENCE BOOKS

- EEE 4512 Lab Manual
- EEE 2106 Lab Manual

EEE 4551 3 hours per week, 3 Cr.
Power Plant Engineering Prerequisite: N/A

Introduction to Thermal Power Plants: Introduction, General Layout of Modern Thermal Power Plant, Working of Thermal Power Plant, Site selection. Fuels, Properties and Their Storage: Introduction, Coal a major fuel for power stations in Bangladesh in the coming years, Analysis of Coal, Classification of Coal, Liquid Fuels, Gaseous Fuels. Coal Handling, Storage, Preparation, and Feeding: Introduction, Out-plant Handling of Coal, Storage of Coal, Coal Crushing,

Burning of Fuels: Coal Burning Methods, Pulverized Fuels and their advantages, Pulverized Fuel Burners, Ash Handling and Dust Collection: Introduction, Ash Handling Systems, Dust Collection and its Disposal, Ash Disposal, Ash and its effects on Boiler Operation and Performance, Utilization of Fly Ash. High Pressure Boilers: Introduction, Advantages of High Pressure Boilers, Super Critical Boilers, Types of Furnaces, Boiler Accessories: Introduction, Economizers, Air Pre-heaters, Super-heaters, Steam Turbines: Classification of Turbines and their working, Compounding of Steam Turbines, Advantages and Disadvantages of Velocity Compounding, Condensers: Introduction, Elements of Steam Condensing Plant, Advantages of Condensers, Cooling Ponds and Cooling Towers: Necessity of Cooling the Condenser waste Water Cooling Methods and Mechanism of Cooling, Introduction to Cooling Ponds, Feed Water Treatment: Necessity of Feed water Treatment, Different Impurities in water, Different Methods of Water Treatment, Diesel Electric Power Plants: Introduction, Outline of Diesel Electric Plant, Types of Engines used for Diesel Power Plants, Plant Layout. Gas Turbine Power Plants: Introduction, Classification and Comparison of different types of Gas Turbine Power plants, Gas and Steam Turbines Combined Cycle: Introduction, arrangement of combined cycles, Advantages of Combined cycle, Waste Heat Recovery System: Introduction, sources of waste and heat and their grading. Nuclear Reactors: Introduction, General components of Nuclear Reactor, Pressurized Water Reactors (PWR), Boiling Water Reactor (BWR), Moderating materials, Control rod materials, Nuclear waste and its disposal. Hydro power plants: Introduction, classification of hydro-electric power plants, Different components of hydro power plant. Non-conventional Power Plants: Solar Park, Hybrid power plants. Generation Scheduling: Deterministic and probabilistic generation, short-term, mid-term and long term load forecasting, Typical Daily Load Curve, Base load, peak load. Demand factor, load factor, capacity factor, utilization factor, Power plant Economics: Economic load sharing between base load and peak load power stations, cost of electricity produced, Types of tariffs, Energy Market: Global Energy Market, Energy resources in Bangladesh, Fuel diversification, Future trends in the market.

SUGGESTED TEXT AND REFERENCE BOOKS

- B. G. A. Skrotzki, W. A. Vopat, and B. G. A. Skrotzki, Power station engineering and economy. New Delhi: Tata McGraw-Hill, 1972.
- P. K. Nag, Power plant engineering. New Delhi: McGraw Hill Education (India) Private, 2015.
- K. Raja, A. P. Srivastava, and M. Dwivedi, Power plant engineering. New Delhi: New Age International (P) Ltd., Publishers, 2006.
- T. Ackermann, Wind power in power systems. Chichester (West Sussex, England): John Wiley, 2012.

EEE 4513 3 hours per week, 3 Cr.
High Voltage Engineering Prerequisite: N/A

High voltage DC: Rectifiers circuits, voltage multipliers, Van-de-Graaf and electrostatic generators; High voltage AC: Cascaded transformers and Tesla coils; Impulse voltage: Shapes, mathematical analysis, codes and standards, single and multi-stage impulse generators, tripping and control of impulse

generators; Breakdown in gas, liquid and solid dielectric materials; Corona; High voltage measurements and testing; Over-voltage phenomenon and insulation coordination; Lightning and switching surges; basic insulation level; surge diverters and arresters.

SUGGESTED TEXT AND REFERENCE BOOKS

- E. Kuffel, W. S. Zaengl, and J. Kuffel, High-voltage engineering: fundamentals. Oxford: Newnes, 2000.
- F. A. M. Rizk and G. N. Trinh, High voltage engineering. Boca Raton, FL: CRC Press, 2014.

EEE 4514 3 hours per week, 1.5 Cr.
High Voltage Engineering Lab Prerequisite: N/A

Laboratory experiments based on theory and concepts learnt in EEE 4513.

SUGGESTED TEXT AND REFERENCE BOOKS

- EEE 4514 Lab Manual

EEE 4571 3 hours per week, 3 Cr.
Power System Protection Prerequisite: EEE 3105, EEE 4511

Introduction to power system protection; Application of Instrument Transformer.
Protection of Low Voltage System: Fuse, MCB, MCCB.
High Voltage Circuit Breaker: Fault clearing process and trip circuit; Trip free feature; Switching phenomena; Arc Extinction; Rating; Current interruption in ACB, OCB, ABCB, SF6 CB, VCB; Switching of capacitor bank & unloaded transmission line; Auto-reclosure; Testing of CB. Surge Arrester.
Protective Relays: Function of protective relays, Electromechanical relays, Numerical relays, Protective zones, Primary & Back up Protection, General requirements of protective relays, actuating quantities of relays, Construction & operating principle of various relays.
Protection Schemes: Over current protection, Distance protection, Pilot Protection, Differential protection, Directional protection, Earth fault protection, Over current relay co-ordination, Protection of ring mains, Three zone distance protection.
Protection Schemes for different devices: Transformer protection, Motor protection, Generator protection, Bus bar protection.

SUGGESTED TEXT AND REFERENCE BOOKS

- Sunil S. Rao, Switchgear Protection and power System, Khanna Publishers; 13th edition
- C. L. Wadhwa, Electrical power systems. London: New Age International (P) Limited Publishers, 2017.

EEE 4572 3 hours per week, 1.5 Cr.
Power System Protection Lab Prerequisite: EEE 3105, EEE 4511, EEE 4512

Laboratory experiments based on theory and concepts learnt in EEE 4571.

SUGGESTED TEXT AND REFERENCE BOOKS

- EEE 4572 Lab Manual

EEE 4591 3 hours per week, 3 Cr.
PLC Prerequisite: EEE 1109, EEE 4105

Introduction to Programmable Logic Controllers: Study and application of various output devices (Relays, electronic switches, DC and servo motor drives, ESC). Understanding the physics and working principle of output devices. Study and use of various Sensors (Limit Switches, Potentiometer, Proximity, Color, Photoelectric & Temperature Sensors) & Actuators. Understanding the triggering conditions and for sensors. Study of different data outputs from the various sensors and learn the process of data acquisition from the sensors.

Overview of Logic and algorithm: Basic overview of algorithm development (AND, OR, Selection, iteration. Fundamentals of PLC Programming. Relating output and input devices through microcontroller coding like Arduino ide, python etc. Understanding plc logic development. Implementing concept of series-parallel switching, timers, delay operations and iterations

Ladder Diagram Programming: Programming Ladder logic diagram. Programming timers and counter in ladder logic. Simulation of various problems using PLC ladder logic. Implementation of PLC: Micrologix PLC Hardware Components. Overview of Micrologix programming interface
Solving various practical problems on Micrologix PLC Hardware

Implementation of PLC: Theoretically solving various practical problems based on Micrologix PLC Hardware and Arduino based microcontroller. Application of plc systems in various production processes like goods sorting, food and can processing, stock maintenance etc.

VFD: Speed/Direction Control of Induction Motor using Variable Frequency Drive, Parameter Programming of VFD for customize control, V/F Curve in VFD, Monitoring of Speed, Load, Direction, Frequency on VFD.

SUGGESTED TEXT AND REFERENCE BOOKS

- Frank D. Petruzella, Programmable Locic Circuits, 4th Edition TATA Mcgraw hill
- Garry A. Dunning, Introduction to Programmable Logic Controller, 3rd edition, Cengage Learning.
- Software: WPLsoft for DELTA PLC (for Ladder logic programming)
- Software: Logo! Soft Demo version for Siemens Logo PLC (programming in Functional Block diagram).

- Manual book of DELTA PLC. [Online]. Available: http://profsite.um.ac.ir/~shoraka/user manual ex-es-ss.pdf. [Accessed: 27-Nov-2020].
- Manual book of Siemens Logo. [Online]. Available: https://cache.industry.siemens.com/dl/files/461/16527461/att_82564/v1/Logo_e.pdf. [Accessed: 27-Nov-2020].

EEE 4592 3 hours per week, 1.5 Cr.
PLC Lab Prerequisite: EEE 1110, EEE 4106

Laboratory experiments based on theory and concepts learnt in EEE 4591.

SUGGESTED TEXT AND REFERENCE BOOKS

- DVP-PLC Application Examples. [Online]. Available: http://www.deltronics.ru/images/manual/DVP-PLC-101_A_EN_20120417.pdf. [Accessed: 27-Nov-2020].
- PLC Lab Manual. [Online]. Available: http://site.iugaza.edu.ps/mhajjo/files/2010/02/PLC.pdf. [Accessed: 27-Nov-2020].

EEE 4515 3 hours per week, 3 Cr.
Power System Operation and Control Prerequisite: N/A

Power System Security
Principles of power system operation, operating states, factors affecting power system security, security analysis, contingency analysis, techniques for contingency analysis- DC load flow and fast decoupled load flow; optimal power flow (OPF)- statement of OPF problem, objective, functions, representation of constraints, solution methods.

Power System Control
Study of modeling- generator, load, prime-mover, governor, tie-line; basic generator control loops; turbine-governor response; static performance of speed governor; generator allocation; AGC implementation; system voltage control methods.

Control Center Operation of Power System
Concept of energy control center: monitoring, data acquisition and control; SCADA; system hardware configurations; EMS functions; wide area monitoring system (WAMS).

Resource scheduling and Commitment
Review of optimization; basic concepts of economic system dispatch- the lossless case, incremental cost, inequality constraints, participation factors, consideration of network losses, penalty factors consideration; unit commitment (UC)-statement of UC problem, different constraints of UC problem, UC solution methods.

State Estimation
Fundamental notions; basis of state estimation; mathematical description of state estimation; minimization technique; least–squares state estimation; bad data identification/ detection; analysis and processing.

SUGGESTED TEXT AND REFERENCE BOOKS

- S. Sivanagaraju, Power System Operation and Control, 1st edition, Pearson India
- N. V. Ramana, Power system operation and control. 2010.

EEE 4533 3 hours per week, 3 Cr.
Power Electronics and Drives Prerequisite: N/A

Fundamental of power electronics.
Characteristics of static power semiconductor devices (BJT, MOSFET, IGBT, IGBT, SCR, IGBT, GTO, TRIAC, UJT and DIAC).

AC/DC power converters
Uncontrolled rectifiers (single phase and three phase), controlled rectifiers (single phase and three phase and dual converter,

AC/AC power converters
Phase controlled converters (single phase and three phase), AC switch.

DC/DC converters
Choppers (step down and step up), switching regulators (buck, boost, buck-boost, Cuk), Design and analysis of DC-DC converters. The discontinuous conduction mode. DC motor control.

DC/AC converters
Single phase and three phase inverters, voltage source and Resonance inverters, PWM inverter. AC motor control; Stepper motor control;

Motor Drives
Induction motor slip power recovery drives: Vector and field oriented control, Volt/Hz control of current-fed Inverter drives, Control and estimation of synchronous motor: Sensorless control.

SUGGESTED TEXT AND REFERENCE BOOKS

- Muhammad H. Rashid, Power Electronics Circuits, Devices and Applications, Third Edition, Prentice-Hall of India Private Limited
- Muhammad H. Rashid, Power Electronics Handbook Devices, Circuits and Applications, 3rd Edition, Elsevier.
- Ned Mohan, Tore M. Undeland & William P. Robbins, Power Electronics Converters, Applications and Design, 2nd edition, John Wiley & Sons Inc.
- Charles A. Schuler and William L. McNamee, Industrial Electronics and Robotics, International Edition, McGraw-Hill.

EEE 4534 3 hours per week, 1.5 Cr.
Power Electronics and Drives Lab Prerequisite: N/A

Laboratory experiments based on theory and concepts learnt in EEE 4533. Design of simple systems using the principles learned in EEE 4533.

SUGGESTED TEXT AND REFERENCE BOOKS

- Muhammad H. Rashid, Power Electronics Circuits, Devices and Applications, Third Edition, Prentice-Hall of India Private Limited
- EEE 4534 Lab Manual
- Muhammad H. Rashid, Power Electronics Handbook Devices, Circuits and Applications, 3rd Edition, Elsevier.
- Ned Mohan, Tore M. Undeland & William P. Robbins, Power Electronics Converters, Applications and Design, 2nd edition, John Wiley & Sons Inc.
- Charles A. Schuler and William L. McNamee, Industrial Electronics and Robotics, International Edition, McGraw-Hill.

EEE 4593 3 hours per week, 3 Cr.
Control System II Prerequisite: EEE 4105

Compensation:
Lead-Lag compensators, PID controllers, application of PID controller in plant and process control, Ziegler–Nichols tuning method of PID controller; design and tuning schemes of PID controller through simulation.

Introduction to nonlinear control:
methods for analysis of nonlinear dynamic systems; linearization; phase-plane analysis; limit cycle; stability of systems using Lyapunov theorems; Controllability and Observability; Adaptive control;

Discrete systems:
Z-transform, state equation and transfer function, state diagrams and state plane analysis; Stability of digital control systems.

Introduction to neutral network:
fuzzy logic, adaptive, and H-infinity control.

SUGGESTED TEXT AND REFERENCE BOOKS

- As per suggestions of concerned faculty members.

EEE 4553 3 hours per week, 3 Cr.
Renewable Energy and Smart Grid Prerequisite: N/A

Introduction to renewable: Environmental impacts of conventional power generation, Renewable energy sources: Solar, Solar-Thermal, wind, mini-hydro, geothermal, biomass, wave and tidal energy, Energy forecasting.
Solar Photovoltaic: Characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, Maximum power point tracking (MPPT), Design of stand-alone PV system, Grid connected PV system, Challenges in grid-integration.
Wind turbines: Power in wind, Betz's law, Wind turbine types and their comparison, Wind turbine generator Permanent magnet synchronous generator and doubly fed induction generator. active and reactive power control.

Introduction to Smart grid: Comparison between conventional and smart grid, distributed generation and energy storage, Bi-directional power flow, Microgrid and its operation modes, Electric vehicles.
Data communication: wireless communication techniques, Power Line Carrier, cyber security.
Demand Side Management: Energy efficiency, Demand response, Smart meters and AMI advanced metering infrastructure.

SUGGESTED TEXT AND REFERENCE BOOKS

- Gilbert M. Masters, Renewable and Efficient Electric Power Systems, John Wiley & Sons, 2004
- J. Ekanayake, K. Liyanage, J. Wu, A. Yokoyama, M. Jenkins, Smart Grid: Technology and Applications, John Wiley and Sons, 2012.
- James Momoh, Smart Grid-Fundamentals of Design and Analysis, IEEE Press, Wiley, 2012.
- Leon Freris, David Infield, Renewable Energy in Power Systems, John Wiley & Sons, 2008
- Ali Keyhani, Design of smart power grid renewable energy systems, IEEE and John Wiley & Sons, 2011
- Mohamed Abdelaziz Mohamed, Mohamed, Ali Mohamed Eltamaly, Modeling and Simulation of Smart Grid Integrated with Hybrid Renewable Energy Systems, Springer International Publishing, 2018

EEE 4555 3 hours per week, 3 Cr.
Nuclear Power Engineering Prerequisite: N/A

Introduction to Nuclear Power: Nuclear radiation, Nuclear fission, Reactor fuels.

Reactor Heat Transfer: Fundamentals of Thermodynamics, Thermal Energy Generation.

Systems Overview: Nuclear Power Plant Components, Types of Nuclear Reactors, Major Components of Nuclear Reactors, coolant system.

Integrated Plant Operation: Plant Startup, Operation, Shutdown, Cool Down.

Reactor Protection and Safeguards Actuation: Reactor Control System, Nuclear Instrumentation, Turbine Control, Pressurizer Pressure and Level Control

Support Systems: Fuel Handling, Radioactive Waste, Nuclear waste management.

SUGGESTED TEXT AND REFERENCE BOOKS

- John R. Lamarsh, Anthony J. Baratta, Introduction to Nuclear Engineering, 3rd Ed., Prentice Hall, Upper Saddle River, NJ, 2001 (ISBN 0-201-82498-1)

- Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner, Margaret B. Bailey, Principles of Engineering Thermodynamics, Wiley, 2015
- K.S Krane, Introductory Nuclear Physics, Wiley, 1987
- David Bodansky, Nuclear Energy: Principles, Practices, and Prospects, 2nd Ed., Springer, 2004 (ISBN 0-387-20778-3)
- John R. Lamarsh, "Introduction to Nuclear Engineering, 2nd Ed., Addison Wesley, 1983

EEE 4543 3 hours per week, 3 Cr.
Special Electrical Machines Prerequisite: EEE 2105, EEE 4531

Universal motor; Permanent magnet motors; Brushless DC motors; Stepper motor; Reluctance motor; Hysteresis motor; Repulsion motor; Electrostatic motor; Servo motors; Synchro; Resolver; Thermoelectric generators; Linear motors and traction; Flywheels (over view); Conduction/Induction pump; Magnetic levitation; Superconducting machines; Gear motor; Coreless motor; Piezoelectric motors; Piezoelectric generators; PCB motor; Linear generator; Micro-motor.

SUGGESTED TEXT AND REFERENCE BOOKS

- Stephen J. Chapman, Electric Machinery Fundamentals, 4th/5th Edition, Mcgraw Hill Higher Education
- Tony R. Kuphaldt, Lessons in Electric Circuits Volume II – AC, 6th Edition, Koros Press; 2007
- "Special Electrical Machines - Lecture Notes, Study Material and Important Questions, Answers." [Online]. Available at: https://www.scribd.com/document/378009087/Special-Electrical-Machines-Lecture-Notes-Study-Material-and-Important-Questions-Answers. [Accessed on: 27-Nov-2020].

YEAR-4, SEMESTER-1/2
Electronics and Computer Group (Elective)

EEE 4311 3 hours per week, 3 Cr.
Processing and Fabrication Technology Prerequisite: EEE 1203

Monolithic Fabrication Processes and Structures: Substrate materials: Crystal growth and wafer preparation. Basic MOS process, Basic Bipolar process, Photolithographic process, pattern generation, pattern transfer, mask alignment, soft and hard baking, Photomask fabrication. Thermal oxidation, oxide quality, oxide thickness characterization. Cleaning: Surface cleaning, organic cleaning and RCA cleaning. Diffusion: Mathematical model, constant source diffusion, limited source diffusion, two-step diffusion, sheet resistance. Diffusion systems: Boron, Phosphorous, Ion implementation. Growth and deposition of dielectric layers: Thermal oxidation, CVD, plasma CVD, sputtering and silicon-nitride growth Etching: Wet chemical etching, silicon and GaAs etching, anisotropic etching, selective etching, dry physical etching, ion beam etching, sputtering etching and reactive ion etching. Isolation: p-n junction isolation, mesa isolation and oxide isolation, BJT based microcircuits, p-channel and n-channel MOSFETs, complimentary MOSFETs and silicon on insulator devices, Testing,

bonding and packaging. Interconnection, contacts, packaging and testing. Nanofabrication: Electron beam lithography, stamp technology, chemical and organic synthesis technology, nanostructure-based fabrication.

SUGGESTED TEXT AND REFERENCE BOOKS

- S. K. Ghandhi, VLSI fabrication principles. New York: John Wiley & Sons, 1983.
- S. M. Sze, VLSI technology. New York, NY: McGraw-Hill, 1988.

EEE 4331 3 hours per week, 3 Cr.
VLSI I Prerequisite: N/A

Top down design approach, technology trends and design styles. Verilog coding of electronic devices. Threshold voltage, body effect, I_V equations and characteristics, latch-up problems, NMOS inverter, CMOS inverter, pass-transistor and transmission gates. CMOS circuit characteristics and performance estimation: Resistance, Capacitance, rise and fall times, delay, gate transistor sizing and power consumption. Layout design rules and physical design of simple logic gates. Adder, multiplier and memory system, ALU. FPGA, Standard cell based design, Full custom design.

SUGGESTED TEXT AND REFERENCE BOOKS

- N. H. E. Weste and D. M. Harris, CMOS VLSI design: a circuits and systems perspective. India: Pearson India, 2015
- S.M. Kang, CMOS Digital Integrated Circuits Analysis & Design. London: McGraw-Hill Education - Europe, 2014.

EEE 4332 3 hours per week, 1.5 Cr.
VLSI I Lab Prerequisite: N/A

Laboratory experiments based on theory and concepts learnt in EEE 4331. Design of simple systems using the principles learned in EEE 4331.

SUGGESTED TEXT AND REFERENCE BOOKS

- N. H. E. Weste and D. M. Harris, CMOS VLSI design: a circuits and systems perspective. India: Pearson India, 2015.
- S. D. Brown and Z. G. Vranesic, Fundamentals of digital logic with Verilog design. New York: McGraw-Hill, 2014.
- K. Golshan, Physical design essentials: an ASIC design implementation perspective. New York: Springer, 2007.
- Erik Brunvand, Digital VLSI Chip Design with Cadence and Synopsys CAD tools, 1st edition, Pearson, 2009.

EEE 4333 3 hours per week, 3 Cr.
Analog Integrated Circuit Prerequisite: EEE 2103

Analog IC Design: Bipolar, MOS and BiCMOS IC technology and its impact, eggshell analogy, application areas and the future of analog IC design. MOS

device physics and models: Large and small signal models for FET. Amplifiers with passive and active loads, cascade stages and frequency limitation. Multiple current sources/sinks using Bipolar and FET technologies. Current mirrors: Basic, cascade and active current mirrors; influence of channel modulation, mismatched transistors and error in aspect ratios. Wilson current mirror. Constant current or voltage references: Supply voltage and temperature independent biasing, band-gap references; Constant-Gm biasing. Widlar band-gap voltage reference. Differential pairs: Differential vs. single-ended operations of simple amplifiers, differential and common mode voltages, common mode rejection ratio (CMRR), input common mode range (ICMR), transfer characteristics, small signal analysis, and frequency response of differential pairs. Operational amplifiers: Design and analysis of operational amplifiers (Op Amps) using BJTs and FETs, hierarchy in analog integrated circuits for an Op-Amps, internal structure of IC Op-Amps, high-performance Op-Amps.

SUGGESTED TEXT AND REFERENCE BOOKS

- Phillip E. Allen and Douglus R. Holberg, CMOS Analog Circuit Design, 5th Edition, Morgan Kaufmann, or Latest Edition.
- Behzad Razavi, Design of Analog CMOS Integrated Circuit, 1st Edition, McGraw-Hill Education.

EEE 4335 3 hours per week, 3 Cr.
VLSI II Prerequisite: N/A

The objective of the course is to study fundamental techniques for Physical Design Automation and Testing. Topics will cover the broad range of physical design techniques: Circuit Partitioning, Floor-planning, Detailed Placement, Global and Detailed Routing, timing Analysis. Fault models, Fault Simulation, Test generation for Combinational / Sequential circuits and Built in Self-Testing.

SUGGESTED TEXT AND REFERENCE BOOKS

- Andrew B. Kahng, Jens Lienig, Igor L. Markov, Jin Hu,VLSI Physical Design: From Graph Partitioning to Timing Closure, Springer Publishers.
- M. L. Bushnell and V. D. Agrawal, Essentials of Electronic Testing for Digital, Memory, and Mixed-Signal VLSI Circuits, Kluwer Academic Publishers.
- P. K. Lala," Digital circuit Testing and Testability", Academic Press. 1997.

EEE 4336 3 hours per week, 1.5 Cr.
VLSI II Lab Prerequisite: N/A

Laboratory experiments based on theory and concepts learnt in EEE 4335.

SUGGESTED TEXT AND REFERENCE BOOKS

- Andrew B. Kahng, Jens Lienig, Igor L. Markov, Jin Hu, VLSI Physical Design: From Graph Partitioning to Timing Closure, Springer Publishers, ISBN 978-90-481-9590-9

- M. L. Bushnell and V. D. Agrawal, Essentials of Electronic Testing for Digital, Memory, and Mixed-Signal VLSI Circuits, Kluwer Academic Publishers, ISBN: 0-7923-7991-8
- P. K. Lala," Digital circuit Testing and Testability", Academic Press. 1997.

EEE 4313 3 hours per week, 3 Cr.
Optoelectronics Prerequisite: N/A

Optical Properties of Semiconductor: Direct and indirect bandgap materials, radiative and non-radiative recombination, optical absorption, photo-generated excess carriers, minority carrier life time, luminescence and quantum efficiency in radiation. Properties of Light: Particle and wave nature of light, polarization, interference, diffraction and blackbody radiation. Electro-optic effect: Electro-optic effect, accousto-optic effect and magneto-optic devices, Introduction to integrated optics. Light Emitting Diode (LED): Principles, materials for visible and infrared LED, internal and external efficiency, loss mechanism, structure and coupling to optical fibers, Driver circuit, DHLED. Stimulated Emission and Light Amplification: Spontaneous and stimulated emission, Einstein relations, population inversion, absorption of radiation, optical feedback and threshold conditions. Semiconductor Lasers: Population inversion in degenerate semiconductors, laser cavity, operating wavelength, threshold current density, power output, elementary laser diode characteristics, hetero-junction lasers, optical and electrical confinement, Single frequency solid state lasers-distributed Bragg reflector (DBR), distributed feedback (DFB) laser, Solid state laser, Introduction to quantum well lasers, Vertical Cavity Surface Emitting Lasers (VCSELs), optical laser amplifiers, pumping techniques. Photo Detectors: Photoconductors, junction photo-detectors, PIN detectors, avalanche photodiodes and phototransistors, hetero-junction photodiodes, Schottky photodiodes, array detectors including CMOS and CCD arrays, Noise in photodetectors, Photodetector design issues. Solar Cells: Solar energy and spectrum, silicon and Schottky solar cells. Others: Optical amplifier, optical ADC and DAC, Introduction to organic optoelectronics, photonic crystal fiber, LCD.

SUGGESTED TEXT AND REFERENCE BOOKS

- Safa O. Kasap, Optoelectronics and Photonics: Principles and Practices, Pearson.
- Anil Maini, Lasers and Optoelectronics: Fundamentals, Devices and Applications, John Wiley and Sons.
- Shun Lien Chuang, Physics of Optoelectronic Devices, Wiley, 1995
- Oleg Sergiyenko, Optoelectronic Devices and Properties, InTech

EEE 4314 3 hours per week, 1.5 Cr.
Optoelectronics Lab Prerequisite: N/A

Laboratory experiments based on theory and concepts learnt in EEE 4313.

SUGGESTED TEXT AND REFERENCE BOOKS

- EEE 4314 Lab Manual
- Anil Maini, Lasers and Optoelectronics: Fundamentals, Devices and Applications, John Wiley and Sons.
- Shun Lien Chuang, Physics of Optoelectronic Devices, Wiley, 1995
- Oleg Sergiyenko, Optoelectronic Devices and Properties, InTech, 2011

EEE 4391 3 hours per week, 3 Cr.
Microcontroller Based Embedded Systems Prerequisite: EEE 3109

Embedded System: Definition; Inside the embedded system (Processor, Memory, IO controllers, Algorithms, Microcontroller, Microprocessor, FPGA, System-on-chip, and DSP); Embedded systems' security issues. Real-time Operating System: Definition (Computer operating system, Real-time operating system, Monitor program, Control program, Multitasking operating system); Scheduler algorithms; Tasks, threads and processes; Multiprocessor support; Interrupts and exceptions.8-Bit CISC Microcontroller: Physical pin diagram and Pin signals; Internal resources (8-bit byte oriented CPU, 1-bit Boolean CPU, Clock oscillator, General purpose registers, Code memory, Data memory, RAM, Parallel ports, Serial communication port, SPI port, In-system programming port, Timer/Counter, Interrupts, Security bits, and etc.). Instruction set (Data movement, Arithmetic, Logical, Branching, Bit manipulation, and etc.); Interfacing with external code and data memory; 8051 and 6811 CISC microcontrollers. 8-Bit RISC Microcontroller: Physical pin diagram and Pin signals; Internal resources (AVR CPU, Clock oscillator, General purpose registers, Code memory, Data memory, RAM, Parallel ports, Serial communication port, SPI port, In-system programming port, Timer/Counter, PWM, ADC, Interrupts, TWI interface, Internal fuse bits, Security bits, and etc.). Instruction set (Data movement, Arithmetic, Logical, Branching, Bit manipulation, and etc.); Advanced Microcontrollers; Embedded System Design.

SUGGESTED TEXT AND REFERENCE BOOKS

- Golam Mostafa, ATmega328P Microcontroller Laboratory Experiments Manual
- S. R. Ball, Embedded Microprocessor Systems: Real World Design, Newton, Mass. USA.
- T. Wilmshurst, An introduction to the design of small-scale embedded systems. Basingstoke: Palgrave, 2001.
- S. R. Ball and S. R. Ball, Analog interfacing to embedded microprocessor systems. Amsterdam: Elsevier/Newnes, 2004.

EEE 4392 3 hours per week, 1.5 Cr.
Microcontroller Based Embedded Systems Lab Prerequisite: EEE 3110

Laboratory experiments based on theory and concepts learnt in EEE 3209. Design of simple systems using the principles learned in EEE 4391.

SUGGESTED TEXT AND REFERENCE BOOKS

- Golam Mostafa, ATmega328P Microcontroller Laboratory Experiments Manual.
- S. R. Ball, Embedded Microprocessor Systems: Real World Design, Newton, Mass. USA.
- T. Wilmshurst, An introduction to the design of small-scale embedded systems. Basingstoke: Palgrave, 2001.
- S. R. Ball and S. R. Ball, Analog interfacing to embedded microprocessor systems. Amsterdam: Elsevier/Newnes, 2004.

EEE 4371 3 hours per week, 3 Cr.
Introduction to Biomedical Engineering Prerequisite: EEE 1203, EEE 3211

Introduction to Biomedical. Overview of Cardiovascular system: Natural pacemakers of the heart – Introduction to Biomedical Instrumentation and Measurements: Principles of a medical instrumentation system, properties of biomedical instrumentation and measurements. Thermal sensors and measuring circuits. Optical Plethysmography, Pulse Oximetry. Bioelectrical measurements: Surface and needle Electrodes, electrode-equivalent circuits, Noise & CMRR considerations, Instrumentation (Bioelectric) amplifier. Electrocardiography: Vector cardiography. EMG Instrumentation EEG. Instrumentation and measurement. Evoked response measurement, signal averaging, Sensory & Motor Nerve conduction velocity measurement. Blood pressure measurement. Defibrillator, Pacemaker. Muscle & Nerve stimulators. Introduction of Bioelectricity, Bio-impedance: Theory of measurement of Bio impedance: electrodes, electrode-electrolyte interface; Bio impedance at different frequencies, Electrical equivalent circuit, Cole model, Overview of Electrical Impedance Tomography (EIT). Introduction to different medical imaging modalities. Basic of Ultrasound Imaging: Overview of X-ray imaging and X-ray CT:). Basic concepts of Magnetic Resonance Imaging (MRI): Telemedicine basic concepts, Patient Safety and regulatory issues.

SUGGESTED TEXT AND REFERENCE BOOKS

- L. Cromwell, E. A. Pfeiffer, and F. J. Weibell, Biomedical instrumentation and measurements. New Delhi: Prentice Hall of India, 2014.
- J. R. Cameron and J. G. Skofronick, Medical physics. New York: Wiley, 1980.
- B.H Brown et al., Medical Physics and Biomedical Engineering (Medical Science Series), 1st edition, CRC Press, 1998
- J. G. Webster, A. J. Nimunkar, J. W. Clark, Medical instrumentation application and design. Hoboken, NJ: Wiley, 2020.

EEE 4372 3 hours per week, 1.5 Cr.
Introduction to Biomedical Engineering Lab Prerequisite: EEE 1203, EEE 1204, EEE 3211, EEE 3212

Laboratory experiments based on theory and concepts learnt in EEE 4371. Design of simple systems using the principles learned in EEE 4371.

SUGGESTED TEXT AND REFERENCE BOOKS

- L. Cromwell, E. A. Pfeiffer, and F. J. Weibell, Biomedical instrumentation and measurements. New Delhi: Prentice Hall of India, 2014.

- J. R. Cameron and J. G. Skofronick, Medical physics. New York: Wiley, 1980.
- B.H Brown et al., Medical Physics and Biomedical Engineering (Medical Science Series), 1st edition, CRC Press, 1998.
- J. G. Webster, A. J. Nimunkar, J. W. Clark, Medical instrumentation application and design. Hoboken, NJ: Wiley, 2020.

EEE 4351 3 hours per week, 3 Cr.
Nano Electronics Prerequisite: N/A

Nanotechnology: importance, size scales, quantum size effects, revolutionary applications, potentials. Quantum mechanics for Nano Devices Quantum theory of semiconductors and carrier transport: Energy bands, density of states, quantum well and dots, band gap energy, Fermi energy, carrier concentration, diffusive and ballistic transport, phonons, Nano MOSFETs and Quantum Well Devices: MOSFETs and advanced concepts, Nano MOSFETs, Ballistic Nano Transistors, Resonant tunnelling devices and Ferroelectric field effect transistors (FeFET) Quantum Wire Devices: Quantum transport in quantum wire, Ballistic Nano Wire Transistors; Quantum Dot Devices: Coulomb Blockade, Single Electron Transistors (SET)Carbon Nanotube, graphene and their applications Spintronics and super conducting properties, and their devices NEMS Devices: stress in thin films, mechanical to electrical transduction, surface engineering techniques, process flow, NEMS actuators, high aspect ratio system technology. Nano Bio Devices: scope and dimensions; detection of biological species on electrical, mechanical and optical criteria; Bio functionality on silicon; Biochip sensors and system-structures, process technology.

SUGGESTED TEXT AND REFERENCE BOOKS

- Charles P. Poole Jr. and Frank J. Owens, “Introduction to Nanotechnology,” 2003, John Wiley & Sons, ISBN: 0471079359.
- Massimiliano Di Ventra, Stephane Evoy and James R. Heflin Jr. (Editors), “Introduction to Nanoscale Science and Technology, Kluwer Academic Publishers, 2004, ISBN: 1402077203.
- Mark A. Reed and Takhee Lee (Editors), Molecular Nanoelectronics, American Scientific Publishers, 2003, ISBN: 1588830063.
- V. V. Mitin, V. A. Kochelap, and M. A. Stroscio, Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications. Cambridge: Cambridge University Press, 2012.

EEE 4393 3 hours per week, 3 Cr.
Computer Architecture Prerequisite: EEE 2103

Instructions and data access methods; Arithmetic Logic Unit (ALU) design: arithmetic and logical operations, floating point operations; Process design: data paths single cycle and multi cycle implementations; Control Unit Design: hardware and micro programmed Pipeline: pipeline data path and control, hazards and exceptions; Memory Organization: cache, virtual memory, buses, multiprocessor, type of microprocessor performance, single bus

multiprocessors, clusters; Multicore , Cell computing; High Performance Computing (HPC).

SUGGESTED TEXT AND REFERENCE BOOKS

- Charles P. Poole Jr. and Frank J. Owens, "Introduction to Nanotechnology," 2003, John Wiley & Sons, ISBN: 0471079359.
- 17.2. Recommended (if any)
- Massimiliano Di Ventra, Stephane Evoy and James R. Heflin Jr. (Editors), "Introduction to Nanoscale Science and Technology, Kluwer Academic Publishers, 2004, ISBN: 1402077203.
- Mark A. Reed and Takhee Lee (Editors), Molecular Nanoelectronics, American Scientific Publishers, 2003, ISBN: 1588830063.
- V. V. Mitin, V. A. Kochelap, and M. A. Stroscio, Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications. Cambridge: Cambridge University Press, 2012.

EEE 4345 3 hours per week, 3 Cr.
Semiconductor Devices Prerequisite: EEE 2213, EEE 3203, EEE 4311

Introduction to Semiconductor devices, classification and applications, Band structure: Bloch theorem, isotropic and anisotropic crystal, band diagram and effective masses of different semiconductor and alloys
Lattice vibration: Simple harmonic model, dispersion relation, acoustic and optical phonons. Free electron model: Electrical conductivity Scattering theory: Review of classical theory, perturbation theory, Fermi-Golden rule, scattering of different processes, scattering mechanism in different semiconductors, mobility, elastic scattering by non-randomly positioned ionized impurities in semiconductors, inter-band and inter-sub-band optical absorption. Review of Different carrier transport models: Continuity equation, drift diffusion theory, Generation and recombination of carriers, ambipolar transport, Different carrier transport models and Methods: Hydrodynamic model, Monte Carlo Method, Boltzmann transport equations. Different carrier Measurement Techniques: PCD measurement of carrier lifetime, CV measurement of carrier and doping density, Thickness Measurement (Elipsometry), Van der paw Mobility measurement. Compound semiconductor: Zinc-blend crystal structure, growth techniques, alloys, band gap, density of carriers in intrinsic and doped compound semiconductors. Hetero-junctions: Band alignment, band offset, Anderson's rule, single and double sided hetero-junctions, quantum wells and quantization effects, lattice mismatch and strain and common hetero-structure material systems. Hetero-junction diode: Band bending, carrier transport and I-V characteristics. Hetero-junction field effect transistor: Structure and principle, band structure, carrier transport and I-V characteristics, Non-ideal effects, frequency response, high electron mobility transistor (HEMT), MESFET, LAOS. Hetero-structure bipolar transistor: Structure and operating principle, quasi-static analysis, secondary effects and band diagram of a graded alloy based HBT.

SUGGESTED TEXT AND REFERENCE BOOKS

- Charles P. Poole Jr. and Frank J. Owens, "Introduction to Nanotechnology," 2003, John Wiley & Sons, ISBN: 0471079359.
- Massimiliano Di Ventra, Stephane Evoy and James R. Heflin Jr. (Editors), "Introduction to Nanoscale Science and Technology, Kluwer Academic Publishers, 2004, ISBN: 1402077203.
- Mark A. Reed and Takhee Lee (Editors), Molecular Nanoelectronics, American Scientific Publishers, 2003, ISBN: 1588830063.
- V. V. Mitin, V. A. Kochelap, and M. A. Stroscio, Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications. Cambridge: Cambridge University Press, 2012.

EEE 4317 3 hours per week, 3 Cr.
Introduction to MEMS Devices Prerequisite: N/A

Introduction: Introduction to MEMS & Microsystems, Market Survey, Application of MEMS. Microscale physics Scaling of Forces in the Microworld, Mechanics of Materials for MEMS, MEMS Materials Properties e.g. chemical resistance, corrosion, mechanical properties, residual, intrinsic stress etc., MEMS design methods. Microelectronic Technology for MEMS. Noise in MEMS device. Interface Electronics for MEMS. MEMS Fabrication Techniques: Bulk micromachining, surface micromachining, CMOS micromachining, bonding technologies, soft-lithography, Photolithography, dry and wet etching process, thin film deposition, metal deposition and etching, Non-lithographical micromachining such as LIGA and laser-assisted processing, process integration. Case studies: Electrostatic, Piezoresistive, electromechanical, capacitive transducer and actuator. Accelerometer, Gyro Sensor. Emerging technology overview of BioMEMS, RF MEMS and Microfluidics. Lab on chip, Optical MEMS, & Carbon Nano Tubes. Introduction to NEMS.

SUGGESTED TEXT AND REFERENCE BOOKS

- Charles P. Poole Jr. and Frank J. Owens, "Introduction to Nanotechnology," 2003, John Wiley & Sons, ISBN: 0471079359.
- Massimiliano Di Ventra, Stephane Evoy and James R. Heflin Jr. (Editors), "Introduction to Nanoscale Science and Technology, Kluwer Academic Publishers, 2004, ISBN: 1402077203.
- Mark A. Reed and Takhee Lee (Editors), Molecular Nanoelectronics, American Scientific Publishers, 2003, ISBN: 1588830063.
- V. V. Mitin, V. A. Kochelap, and M. A. Stroscio, Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications. Cambridge: Cambridge University Press, 2012.

EEE 4395 3 hours per week, 3 Cr.
Introduction to MEMS Devices Prerequisite: EEE 1203, EEE 2103, EEE 3109, EEE 3211, EEE 3217, EEE 4105

Introduction: Overview, brief history, and preliminaries

Types and construction of robots: Domestic/household robots, medical robots, Agricultural robot, caterpillar robots, military robots etc. with their components; Components of robot: Sensors/detectors/transducers: Gyro, sound, sonar, tilt, flux, proximity, force, temperature, humidity, moisture, color, flame, smoke, methane gas, carbon monoxide gas etc. Modules: Blue tooth, RF (Radio frequency), GSM (Global System for Mobile communication), Introduction to some of the hardware: keypad, displays, effectors/actuators, Li-Po battery etc. Translations and rotations, position and orientation: Rotation representation, coordinate transformation Kinematics (Direct and inverse kinematics), Kinematic chains, loop kinematics systems, Link transformation: Closed and open loop kinematics system, Kinematic constrains: Degree of freedom and mobility, implementing inverse kinematics using Jacobean Equations of motion, rigid motions mechanism and manipulators dynamics, dynamic equations, Inverse and forward dynamic algorithm, dynamic modeling, dynamic formulation, time response of dynamic system, optimal control, dynamic effects of feed-back control robot navigation, human robot interaction (HRI), artificial intelligence and its implementation in robotics Optimization, Image processing Properties of robot Communication, information and machine learning, Single joint control, control by feedback linearization Parameters estimations, Adaptive/robust control Path planning, inertial navigation task planning and multi agent systems, Simple walking/running model autonomous robots, mobile robots, articulated robots, flying robots, flapping flight motion, and dynamics Swimming robots, probabilistic robotics, behavior based control.

SUGGESTED TEXT AND REFERENCE BOOKS

- J. J. Craig, Introduction to robotics: mechanics and control. Chennai: Pearson, 2008.
- S. B. Niku, Introduction to robotics: analysis, control, applications. Hoboken, NJ: Wiley, 2020.
- Neil Wilkins, Artificial Intelligence: The Ultimate Guide to AI, The Internet of Things, Machine Learning, Deep Learning + a Comprehensive Guide to Robotics, Bravex Publications.
- C. S. G. Lee, R. C. Gonzalez, and K. S. Fu, Robotics. Silver Spring, MD: IEEE Computer Society Press, 1983.
- Y. Koren, Robotics for engineers. New York, NY: McGraw-Hill, 1985.

EEE 4396 3 hours per week, 1.5 Cr.
Introduction to MEMS Devices Prerequisite: N/A

Laboratory experiments based on theory and concepts learnt in EEE 4395. Design of simple systems using the principles learned in EEE 4395.

SUGGESTED TEXT AND REFERENCE BOOKS

- J. J. Craig, Introduction to robotics: mechanics and control. Chennai: Pearson, 2008.
- S. B. Niku, Introduction to robotics: analysis, control, applications. Hoboken, NJ: Wiley, 2020.
- Neil Wilkins, Artificial Intelligence: The Ultimate Guide to AI, The Internet of Things, Machine Learning, Deep Learning + a Comprehensive Guide to Robotics, Bravex Publications.

- C. S. G. Lee, R. C. Gonzalez, and K. S. Fu, Robotics. Silver Spring, MD: IEEE Computer Society Press, 1983.
- Y. Koren, Robotics for engineers. New York, NY: McGraw-Hill, 1985.

YEAR-4, SEMESTER-1/2

Communication and Signal Processing Group (Elective)

EEE 4715 3 hours per week, 3 Cr.

Advanced Digital Signal Processing Prerequisite: EEE 3217

Multirate digital signal processing: interpolation and decimation, poly-phase representation, multistage representation. Sensor array signal processing: adaptive signal processing and filtering, applications. Representation of random signal: deterministic and stochastic signals, power spectral density, autocorrelation. Wavelet transform: continuous wavelet transforms and discrete wavelet transform. Implementation of DWT using FIR filter banks. Sub-Nyquist sampling: reconstruction of sparsely sampled signals. Independent Component Analysis (ICA) and Principal Component Analysis of real world signal.

SUGGESTED TEXT AND REFERENCE BOOKS

- S. W. Smith, The Scientist and Engineer's Guide to Digital Signal Processing, 2nd ed. California: California Technical Publishing, 1999.
- B. P. Lathi and R. Green, Essentials of Digital Signal Processing. New York, NY: Cambridge University Press, 2014.
- K. A. K. Ossman, Introduction to Digital Signal Processing Theory and Applications Using MATLAB. Cincinnati, OH, 2017.
- J. G. Proakis and D. G. Manolakis, Digital Signal Processing, Principles, Algorithm, and Applications, 4th ed. New Delhi, India: Pearson, 2009.
- J. M. Giron-Sierra, Signal Processing with Matlab Examples, Volume 1. Singapore: Springer, 2017.

EEE 4733 3 hours per week, 3 Cr.

Microwave Engineering Prerequisite: EEE 3117

Introduction to microwave engineering; Transmission lines: Voltage and current in transmission lines, reflection, transmission, input impedance, impedance transformation, impedance matching, standing wave ratio. Planar transmission-lines; Waveguides: rectangular and circular waveguides, modes of operation. Resonant cavities: Energy storage, losses and quality factor (Q). Waveguide junctions or Tees. Network analysis: impedance and equivalent voltage and current, impedance and admittance matrix, scattering matrix. Two-port network, S-parameters. Quarter wave transformer, ABCD matrix, signal flow graph. Power dividers and directional couplers. Microwave sources. Active devices and amplifiers: detector, mixer, switches, phase shifters, attenuators, low noise amplifiers. Oscillators, filters. Radiation: Small current element, radiation resistance, radiation pattern and properties. Microwave antennas: dipole, loop, microstrip, horn antenna, array, smart antennas.

SUGGESTED TEXT AND REFERENCE BOOKS

- D. M. Pozar, Microwave Engineering, 4th ed. Hoboken, NJ: John Wiley & Sons, 2011.
- F. T. Ullaby et. al., Fundamental of Applied Electromagnetics, 6th ed. New York, NY: Pearson, 2015.
- S. Ramo et. al., Fields and Waves in Communication Electronics, 3rd ed. New Delhi, India: Wiley India Edition, 2007.
- C. A. Balanis, Antenna Theory: Analysis and Design, 3rd ed. New Delhi, India: John Wiley, 2005.
- S. Gupta, Electronics Communications Systems. New Delhi, India: Khanna Publishers, 1996.
- G. S. Raghuvanshi, Microwave Engineering. Boston, MA: Cengage Learning, 2012.
- S. Gupta, Microwave Engineering, 3rd ed. New Delhi, India: Khanna Publishers, 2011.

EEE 4734 3 hours per week, 1.5 Cr.
Microwave Engineering Lab Prerequisite: N/A

Laboratory experiments based on theory and concepts learnt in EEE 4733. Design of simple systems using the principles learned in EEE 4733.

SUGGESTED TEXT AND REFERENCE BOOKS

- EEE 4734 Lab Manual.
- D. M. Pozar, Microwave Engineering, 4th ed. Hoboken, NJ: John Wiley & Sons, 2011.
- C. A. Balanis, Antenna Theory: Analysis and Design, 3rd ed. New Delhi, India: John Wiley, 2005.
- S. Gupta, Electronics Communications Systems. New Delhi, India: Khanna Publishers, 1996.
- G. S. Raghuvanshi, Microwave Engineering. Boston, MA: Cengage Learning, 2012.
- S. Gupta, Microwave Engineering, 3rd ed. New Delhi, India: Khanna Publishers, 2011.

EEE 4735 3 hours per week, 3 Cr.
Optical Fiber Communication Prerequisite: EEE 3117, EEE 3207

Basic concept of optical fiber communication system. Definitions: critical angle, Brewster angle, numerical aperture. Modes of propagation, phase velocity and group velocity. Types of polarization. Fibers: step index, graded index, single mode, and multimode. Attenuation, bending loss, and splice loss. Dispersions: modal dispersion, group velocity dispersion, polarization mode dispersion, chromatic dispersion. Dispersion shifter and dispersion compensated fibers. Nonlinear effects: Raman, Brillouin, and Kerr effect. Self- and cross-phase modulation, four-wave mixing. Optical sources: LED characteristics, structures, applications. LASER: working principles, structures, and applications. Optical modulators: EOPM, EOIM, Mach-Zehnder interferometer, electro-optic directional coupler. Optical filter, optical switch. Multiplexing techniques: OFDM, OTDM, O-CDMA, and WDM. Optical

amplifiers: SLA (SOA), EDFA, YDFA, Gain characteristics, Regenerative repeaters, Raman amplifiers. Optical MUX/DMUX: MZI, FBG (Fiber Bragg Grating), AWG. Principles of photo detection. Photodiodes: PN, PIN, avalanche photo detectors. Optical receivers: direct detection, heterodyne detection, coherent receiver. Performance of receivers: receiver noises, sensitivities, SNR, BER. Fiber manufacturing. Fiber joints & coupler. Optical network: SDH, SONET, power budget, and bandwidth budget.

SUGGESTED TEXT AND REFERENCE BOOKS

- J. M. Senior, Optical Fiber Communications, 3rd ed. New Delhi, India: Pearson, 2010.
- G. Keiser, Optical Fiber Communications, 4th ed. New Delhi, India: Tata McGraw Hill, 2008.
- H. J. R. Dutton, Understanding Optical Communications. Upper Saddle River, NJ: Prentice Hall, 1998.
- J. Palais, Fiber Optic Communications, 5th ed. New Delhi, India: Pearson, 2005.
- S. O. Kasap, Optoelectronics and Photonics. New Delhi: India, Pearson, 2009.
- J. Wilson and J. Hawkes, Optoelectronics an Introduction, 3rd ed. Upper Saddle River, NJ: Prentice Hall, 1998.
- G. P. Agrawal, Fiber-Optic Communication Systems. New Delhi, India: Wiley, 1997.

EEE 4736 3 hours per week, 1.5 Cr.
Optical Fiber Communication Lab Prerequisite: EEE 3117, EEE 3207

Laboratory experiments based on theory and concepts learnt in EEE 4735.

SUGGESTED TEXT AND REFERENCE BOOKS

- EEE 4736 Lab Manual.
- J. M. Senior, Optical Fiber Communications, 3rd ed. New Delhi, India: Pearson, 2010.
- G. Keiser, Optical Fiber Communications, 4th ed. New Delhi, India: Tata McGraw Hill, 2008.
- H. J. R. Dutton, Understanding Optical Communications. Upper Saddle River, NJ: Prentice Hall, 1998.
- J. Palais, Fiber Optic Communications, 5th ed. New Delhi, India: Pearson, 2005.
- S. O. Kasap, Optoelectronics and Photonics. New Delhi: India, Pearson, 2009.
- J. Wilson and J. Hawkes, Optoelectronics an Introduction, 3rd ed. Upper Saddle River, NJ: Prentice Hall, 1998.
- G. P. Agrawal, Fiber-Optic Communication Systems. New Delhi, India: Wiley, 1997.

EEE 4719 3 hours per week, 3 Cr.
Random Signals and Processes Prerequisite: EEE 3217

Introduction to probability theory and random variables: Distribution, properties, density functions and conditionals probability. Expectation: Moments and characteristic functions. Transformation of a random variable. Vector random variables. Joint distribution and density. Sum of random variables. Representation of random signals: Deterministic and stochastic signals; power spectral density, autocorrelation, cross correlation. Gaussian and

Poisson random processes. Noise models. Response of linear systems to random inputs. Introduction to Discrete Time processes: Mean square estimation, detection and linear filtering. Applications: Case studies.

SUGGESTED TEXT AND REFERENCE BOOKS

- J. J. Shynk, Probability, Random Variables, and Random Processes: Theory and Signal Processing Applications. Hobokan, NJ: John Wiley & Sons, 2012.
- J. G. Proakis and D. G. Manolakis, Digital Signal Processing, Principles, Algorithm, and Applications, 4th ed. New Delhi, India: Pearson, 2009.
- K. A. K. Ossman, Introduction to Digital Signal Processing Theory and Applications Using MATLAB. Cincinnati, OH, 2017.
- G. S. Raghuvanshi, Microwave Engineering. Boston, MA: Cengage Learning, 2012.

EEE 4725 3 hours per week, 3 Cr.
Digital Communication Systems Prerequisite: N/A

Introduction to digital communication systems. Digital Communication channels: Band limited channels, AWGN channel, fading channels, base band digital transmission, bandwidth, power efficiency. Inter Symbol Interference (ISI), pulse shaping, adaptive equalization, eye diagram, partial response signaling. Probability Theory: probability space, independence expectation, conditional expectation, Baye's rule, stochastic processes. Elements of Information Theory: Entropy for discrete signals, randomness, self-information, mutual information, entropy rate for Markov sources. Source coding: Huffman coding, Shannon-Fano coding, Shannon's first theorem, linear predictive coding. Modulation: PCM, Delta modulation, adaptive delta modulation, differential PCM, and coding trade-off; Optimal Receiver Design: General binary and M-ary signaling, correlation demodulator, match filter demodulator and maximum likelihood receiver; Performance in an AWGN channel: The Chernoff and union/Chernoff bounds, simulation techniques; Channel capacity: Channel capacity, Shannon's second theorem, capacity of a band-limited Gaussian channel; Channel coding: Block codes, hard and soft-decision decoding, performance Convolutional codes, the Viterbi algorithm, performance bounds Trellis-coded modulation (TCM). Spread spectrum communication systems: direct sequence and frequency hopped spread spectrum signals; Rake receivers, multi-user detection.

SUGGESTED TEXT AND REFERENCE BOOKS

- B. P. Lathi, Modern Digital and Analog Communication Systems, 3rd ed. New York, NY: Oxford University Press, 1988.
- S. S. Haykin, Communication systems, 2nd ed. New York, NY: Wiley, 1994.
- B. A. Forouzan and S. C. Fegan, Data Communication and Networking, 4th ed. New York: NY: McGraw-Hill, 2007.
- J. C. Bellamy, Digital Telephony, 3rd ed. New Delhi, India: Wiley, 2004.
- V. K. Mehta, Principle of Electronics. New Delhi, India: S. Chand Publishing, 1980.

EEE 4726 3 hours per week, 1.5 Cr.

Digital Communication Systems Lab Prerequisite: N/A

Laboratory experiments based on theory and concepts learnt in EEE 4725.

SUGGESTED TEXT AND REFERENCE BOOKS

- EEE 4726 Lab Manual.
- B. Sklar, Digital Communications Fundamentals and Applications, 2nd ed. Upper Saddle River, NJ: Prentice Hall, 2001.
- S. S. Haykin, Communication systems, 2nd ed. New York, NY: Wiley, 1994.

EEE 4729 3 hours per week, 3 Cr.
Wireless Communications Prerequisite: EEE 3207

Introduction: overview of wireless communications and its evolution, review of elements of a digital communication system. Cellular radio system: history of cellular systems, frequency reuse, interference and system capacity, sectorization, cell splitting, components of cellular systems. Frequency management and channel assignment: fundamentals, spectrum utilization, fundamentals of channel assignment, traffic and channel assignment. Handoffs and dropped calls: reasons and types, forced handoffs, mobile assisted handoffs and dropped call rate. Radio propagation from mobile systems: propagation characteristics, models for radio propagation, systems components. Antenna at cell site and mobile antenna. Impact of fading and ISI. Fading mitigation techniques: concept of diversity branch and signal paths, carrier to noise and carrier to interference ratio. Flat fading counter measures: diversity, adaptive modulation, OFDM, MIMO. ISI counter measures: OFDM, multi user systems. Multiple access techniques: FDMA, TDMA, WCDMA, ALOHA, slotted ALOHA, CSMA. Wireless communication networks: WLAN, WiMAX. Digital cellular systems: Global System for Mobile Communication (GSM) and its evolution. UMTS: 3G fundamental technologies and systems. 4G fundamental technologies. Long Term Evolution (LTE) Case Study. LTE-Advanced (LTE-A). Case study and future perspectives.

SUGGESTED TEXT AND REFERENCE BOOKS

- T. S. Rappaport, Wireless Communications: Principles and Practice. Upper Saddle River, NJ: Prentice Hall, 1996.
- M. Schwartz, Mobile Wireless Communications. New York, NY: Cambridge University Press, 2005.
- V. K. Garg, Wireless Communications and Networking. Amsterdam, Netherlands, Elsevier, 2007.

EEE 4727 3 hours per week, 3 Cr.
Satellite Communication Engineering Prerequisite: EEE 3207, EEE 4729, EEE 4733

Introduction to Satellite Communication, Satellite frequency bands, satellite orbits, satellite types, regulation of the spectrum and interference, propagation channel, air interfaces, link budget analysis. Satellites as spacecraft: subsystems, antennas, transponders. Access technique for satellite communication: SCPC,

MCPC, SPADE; Spread spectrum communication techniques in Satellite networks. Multi-beam Satellite, inter-Satellite link (ISL). Satellite on-board switching techniques. VSAT technologies, elements of VSAT networks, regulatory issues, benefits of VSATs, applications of VSATs, VSAT network configurations, protocols and interfaces. Earth station technology. Noise temperature. Large Earth station antennas. Digital Audio Broadcasting, Digital Video broadcasting (DVB). Remote sensing.

SUGGESTED TEXT AND REFERENCE BOOKS

- T. Pratt and C. W. Bostian, Satellite communications. New York, NY: Wiley, 1986.
- W. L. Pritchard et. al., Satellite communication systems engineering. Englewood Cliffs, NJ: Prentice Hall, 1993.
- D. Roddy, Satellite communication. New York, NY: McGraw Hill, 2001.
- S. Katiyar, Satellite communication. New Delhi, India: S.K. Kataria & Sons, 2007.
- J. R. Jensen and J. McMorrow, Remote sensing of the environment. Prentice-Hall, 2000.

EEE 4728 3 hours per week, 1.5 Cr.
Satellite Communication Engineering Lab Prerequisite: EEE 3208

Laboratory experiments based on theory and concepts learnt in EEE 4727.

SUGGESTED TEXT AND REFERENCE BOOKS

- K. Maini and V. Agrawal, Satellite Technology: Principles and Applications, 1st ed. Hoboken, NJ: Wiley & Sons, 2007.
- W. L. Pritchard et. al., Satellite communication systems engineering. Englewood Cliffs, NJ: Prentice Hall, 1993.
- L. J. Ippolito, Satellite Communications Systems: Atmospheric Effects, Satellite Link Design and System Performance, 1st ed. Hoboken, NJ: Wiley & Sons, 2008.

EEE 4711 3 hours per week, 3 Cr.
Biomedical Signal Processing Prerequisite: EEE 3107, EEE 3217

Introduction: introduction to human anatomy and cell physiology; Different types of biomedical signals: some typical sources of biomedical signals, deterministic, stochastic, fractal and chaotic signals. Modeling of biomedical signals. Review of basic digital signal processing –elimination of noises, stochastic signals correlation, and power spectral density. Time-frequency analysis: Time-Frequency Distributions, Short-Time Fourier Transform, Discrete Cosine Transform, Wavelet Transform. Linear modeling: autoregressive models, linear prediction, parametric spectral estimation, criteria for model selection. Random signals and probability: Introduction to random variables and probability density functions (PDFs). Adaptive filtering: adaptive prediction, adaptive estimation of transfer functions, adaptive interference cancellation, Wiener filters. Applications of ICA/PCA in biomedical signal processing. Electroencephalogram (EEG), electrocardiogram (ECG), electrocorticogram (ECoG), electromyogram (EMG), electrooculogram (EOG), magnetoencephalogram (MEEG), respiratory sounds, heart sounds, colored

ultra sound; biomedical signal recording system; spectral characteristics of biomedical signals. Emerging techniques in medical signal processing; Case studies: applications of signal processing in clinical instrumentation, imaging and diagnosis.

SUGGESTED TEXT AND REFERENCE BOOKS

- E. N. Bruce, Biomedical signal processing and signal modeling, 1st ed. New York, NY: Wiley, 2009.
- R. Splinter and K. Najarian, Biomedical Signal and Image Processing. CRC Press, 2012.
- S. Cerutti and C. Marchesi, Advanced methods of biomedical signal processing. Piscataway, NJ: IEEE Press, 2011.

EEE 4712 3 hours per week, 1.5 Cr.
Biomedical Signal Processing Lab Prerequisite: EEE 3107, EEE 3217

Laboratory experiments based on theory and concepts learnt in EEE 4711. Design of simple systems using the principles learned in EEE 4711.

SUGGESTED TEXT AND REFERENCE BOOKS

- E. N. Bruce, Biomedical signal processing and signal modeling, 1st ed. New York, NY: Wiley, 2009.
- R. Splinter and K. Najarian, Biomedical Signal and Image Processing. CRC Press, 2012.
- S. Cerutti and C. Marchesi, Advanced methods of biomedical signal processing. Piscataway, NJ: IEEE Press, 2011.

EEE 4713 3 hours per week, 3 Cr.
Speech and Image Processing Prerequisite: EEE 3207, EEE 3217

Speech Processing: Introduction, Speech Production Model, Speech Coding: Objectives and Requirements, Quantizers for Speech Signal, mew - Law and Optimum Quantizer, Adaptive Quantizer, Differential Quantization, LDM and ADM, Differential PCM and Adaptive Prediction, Linear Prediction of Speech, Computational Aspects of LPC parameters, Cholesky Decomposition, Lattice Formulation of LPC Coefficient, Linear Predictive Synthesizer, Vocoder. Hidden Markov Models (HMM), Veterbi Decoding, linguistic knowledge.
Image Processing: Image sampling and quantization, color, point operations, segmentation, morphological image processing, linear image filtering and correlation; Standards of image processing/compression: JPEG, MPEG, H.261, and H.263; image transforms: DCT, eigen images, multiresolution image processing: Wavelet, noise reduction and restoration, feature extraction and recognition tasks.

SUGGESTED TEXT AND REFERENCE BOOKS

- L. R. Rabiner and R. W. Schafer, Digital processing of spe3ech signals. Delhi, India: Pearson Education, 2005.
- Kondoz, Digital Speech: Coding for low bit rate communication systems. Hoboken, NJ: John Wiley, 1994.
- J. Benesty et. al., Springer handbook of speech processing: with DVD-ROM, 456 figures and 113 tables. Berlin, Germany: Springer, 2008.
- H.R. Wu and K.R. Rao, Digital Video Image Quality and Perceptual Coding. Boca Raton, FL: CRC Press, Taylor and Francis Group, 2005.

EEE 4714 3 hours per week, 1.5 Cr.
Speech and Image Processing Lab Prerequisite: EEE 3110, EEE 3218

Laboratory experiments based on theory and concepts learnt in EEE 4713.

SUGGESTED TEXT AND REFERENCE BOOKS

- EEE 4714 Lab Manual.
- J. Benesty et. al., Springer handbook of speech processing: with DVD-ROM, 456 figures and 113 tables. Berlin, Germany: Springer, 2008.
- M. K. Bhuyan, Computer Vision and Image Processing: Fundamentals and Applications, 1st ed. New York, NY: Springer, 2019.
- Pajankar, Python 3 Image Processing: Learn Image Processing with Python 3, NumPy, Matplotlib, and Scikit-image. Kolkata, India: BPB Publication, 2019.

CSE 4723 3 hours per week, 3 Cr.
Data Communication Networks Prerequisite: EEE 3207

Introduction to data communication networks: OSI and TCP/IP model; Different data communication services; Physical layer: wired and wireless transmission media; Introduction to telecommunication system: cellular and satellite communication; Digital data communication technique; Data encoding; Modulation and multiplexing; Short Introduction to circuit switching; Packet switching: routing, VLAN, congestion control, QoS; Data link layer: Elementary protocols, sliding window protocols; Error detection and correction; HDLC; Multiple Access protocols: IEEE.802 protocols for LANs, MANs, WANs; High speed LAN: Ethernet, Token Ring, FDDI ; Network layer in internet: IP protocol, IP addresses (IPv4, IPv6), ARP; Transport layer: transmission control protocol, UDP, Network management and security; Email; Domain name system; Simple network management protocol; HTTP and World Wide Web, Mobile Wireless Network, Mobile IP, Mobile ATM. High-Speed Networks: Broad band access technologies, ISDN and broadband ISDN, PPP, Frame Relay, Asynchronous Transfer Mode (ATM), High-Speed LANs, SONET/SDH, Switched Multimegabit Data Services (SMDS). Introduction to data compression.

SUGGESTED TEXT AND REFERENCE BOOKS

- S. Tanenbaum and N. Feamster, Computer networks. Boston, MA: Pearson Education, 2019.

- W. Stallings, Data and computer communications. New York, NY: Macmillan Pub. Co., 1989.
- G. Held, Understanding data communications: from fundamentals to networking. Chichester, Angleterre: J. Wiley, 2000.
- R. Sarch and G. Held, Data communications: a comprehensive approach. New York, NY: McGraw-Hill, 1995.
- G. Waters, Computer communication networks. London: McGraw-Hill, 1992.

CSE 4724 3 hours per week, 1.5 Cr.
Data Communication Networks Lab Prerequisite: EEE 3207

Laboratory experiments based on theory and concepts learnt in CSE 4723.

SUGGESTED TEXT AND REFERENCE BOOKS

- CSE 4724 Lab Manual.

EEE 4717 3 hours per week, 3 Cr.
Multimedia Communications Prerequisite: EEE 3207

Multimedia information representation: Text, unformatted text, formatted text and hypertext, Image : Graphics and digitized picture, Audio : PCM, CD quality audio and synthesized audio, Video : Broadcast television, Digital video and PC video; Compression principles (Text and Image): Lossless and lossy compression, entropy encoding, source encoding, differential encoding, Text compression : Static Huffman coding, Dynamic Huffman coding, Arithmetic coding, Lempel-Ziv coding, Lempel-Ziv-Welsh coding, Image compression : GIF, TIFF and JPEG; Audio compression : Analog and digital μ-law companding, Differential pulse code modulation (DPCM), Adaptive differential pulse code modulation (ADPCM), Linear predictive coding (LPC); Video compression :Video compression principles, hybrid video codec, frame types, motion estimation and compensation. Application and network terminology: Media types, Communication modes, Network types, Multipoint conferencing, Network QoS, Application QoS; Digitization principles; Transport protocols: TCP, UDP, IP, Ipv4, Ipv6, FTP, RTP, and RTCP; use of MPLS and WDMA; Multimedia synchronization; security; Multimedia networks: Telephone network, Data network, Broadcast television network, Integrated services digital network (ISDN), Broadband multiservice network; Multimedia applications.

SUGGESTED TEXT AND REFERENCE BOOKS

- C. Meinel and H. Sack, Digital Communication, Multimedia, Security. Berlin, Germany: Springer Berlin, 2016.
- F. Halsall, Multimedia communications: applications, networks, protocols, and standards. Delhi, India: Pearson education Asia, 2001.
- S. M. Marques, Multimedia Communications and Networking. Boca Raton, FL: CRC Press, 2016.

- J. D. Gibson, Multimedia communications: directions and innovations. San Diego, CA: Academic Press, 2001.
- Lecture notes. (Available at http://adnan.quaium.com/aust/cse4295)

EEE 4731 3 hours per week, 3 Cr.
Antenna and Wireless Propagation Prerequisite: EEE 3117

Fundamentals of Antenna: principles, antenna parameters; Types of practical antennas: Dipole, Horn, Patch, and other types. Antenna array synthesis, beamforming; EM waves: properties; Link-budget analysis; Intelligent Antennas: Diversity, fading, shadowing, Adaptive Antennas, Equalizers; Theory of Ultra Wide Band (UWB) Antenna: Planar Microstrip monopole, time-domain characteristics of monopole, UWB beam forming; Design of Antenna: Design of patch antenna, S-parameters; Propagation mechanism: propagation channels, propagation channel models: ray tracing, FDTD, UWB channel modelling; Applications of antennas: antenna for signal processing.

SUGGESTED TEXT AND REFERENCE BOOKS

- C. A. Balanis, Antenna theory: analysis and design. Hoboken, NJ: Wiley, 2016.
- J. D. Kraus and R. J. Marhefka, Antennas for all applications. Boston, MA: McGraw-Hill, 2008.
- K. D. Prasad and D. Handa, Antenna and wave propagation. New Delhi, India: Satya Prakashan, 2003.
- R. Chatterjee, Antenna theory and practice, 2nd ed. New Delhi, India: New Age International, 1996.

EEE 4732 3 hours per week, 1.5 Cr.
Antenna and Wireless Propagation Lab Prerequisite: N/A

Laboratory experiments based on theory and concepts learnt in EEE 4731. Design of simple systems using the principles learned in EEE 4731.

SUGGESTED TEXT AND REFERENCE BOOKS

- EEE 4732 Lab Manual.