MODEL CURRICULUM

for

UNDERGRADUATE DEGREE COURSES
IN

ELECTRICAL ENGINEERING

(Engineering & Technology)

[January 2018]

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION
Nelson Mandela Marg, Vasant Kunj, New Delhi 110 070
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All India Council for Technical Education
Model curriculum for
Undergraduate Degree Courses in Engineering & Technology

ELECTRICAL ENGINEERING

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ELECTRICAL ENGINEERING

Chapter-1
General, Course structure & Theme
&
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Section -1

A. **Definition of Credit**:

1 Hr. Lecture (L) per week	1 credit
1 Hr. Tutorial (T) per week	1 credit
1 Hr. Practical (P) per week 2 Hours Practical(Lab)/week	0.5 credits 1 credit

B. **Range of credits -**A range of credits from 150 to 160 for a student to be eligible to get Under Graduate degree in Engineering. A student will be eligible to get Under Graduate degree with Honours or additional Minor Engineering, if he/she completes an additional 20 credits. These could be acquired through MOOCs.

C. **Structure of Undergraduate Engineering program:**

Sl. No.	Topic	**Credits of the EE Curriculum**
1.	Humanities and Social Sciences including Management	12
2.	Basic Sciences	26
3.	Engineering Sciences including workshop, drawing, basics of electrical/mechanical/computer etc.	20
4.	Professional Core Subjects	53
5.	Professional Subjects: Subjects relevant to chosen specialization/branch	18
6.	Open Subjects: Electives from other technical and/or emerging subjects	18
7.	Project work, seminar and internship in industry or elsewhere	11
8.	Mandatory Courses [Environmental Sciences, Induction Program, Indian Constitution, Essence of Indian Knowledge Tradition]	Non-credit
	Total	**158**

D. Credit distribution in the First year of Undergraduate Engineering program:

	Lecture	Tutorial	Laboratory/Practical	Total credits
Chemistry-I	3	1	3	5.5
Physics-I	3	1	3	5.5
Mathematics-I	3	1	0	4
Mathematics –II	3	1	0	4
Programming for Problem solving	3	0	4	5
English	2	0	2	3
Engineering Graphics	1	0	4	3
Workshop/ Practical	1	0	4	3
Basic Electrical Engg.	3	1	2	5

E. List of Basic Science and Engineering Science Courses that may be taken in 2nd year:

	Lecture	Tutorial	Laboratory/Practical	Total credits
Mathematics-III	3	1	0	4
Biology-I	2	1	0	3
Engineering Mechanics	3	1	0	4

F. Course code and definition:

Course code	Definitions
BSC	Basic Science Courses
ESC	Engineering Science Courses
HSMC	Humanities and Social Sciences including Management courses
PCC-EE	Professional core courses
PEC-EE	Professional Elective courses
OEC-EE	Open Elective courses
LC	Laboratory course
MC	Mandatory courses
PROJ-EE	Project

Section 2:

BASIC SCIENCE COURSES

Sr. No.	Course Code	Course Title	Hrs. /Week L: T: P	Credits	Preferred Semester
1	BSC 101	Mathematics – I (Calculus and Differential Equations)	3:1:0	4	I
2	BSC 102	Physics (Waves and Optics, and Introduction to Quantum Mechanics)	3:1:3	5.5	I
3	BSC 103	Mathematics – II (Linear Algebra, Transform Calculus and Numerical Methods)	3:1:0	4	II
4	BSC 104	Chemistry – I	3:1:3	5.5	II
5	BSC 201	Mathematics – III (Probability and Statistics)	3:1:0	4	IV
6	BSC 202	Biology – I	2:1:0	3	IV
		Total		26	

ENGINEERING SCIENCE COURSES

Sr. No.	Course Code	Course Title	Hrs. /Week L: T: P	Credits	Preferred Semester
1	ESC 101	Programming for Problem Solving	3:0:4	5	II
2	ESC 102	Workshop/Manufacturing Practices	1:0:4	3	II
4	ESC 103	Engineering Graphics	1:0:4	3	I
5	ESC 104	Basic Electrical Engineering	3:1:2	5	I
6	ESC 201	Engineering Mechanics	3:1:0	4	III
		Total		20	

HUMANITIES & SOCIAL SCIENCES INCLUDING MANAGEMENT

Sr. No.	Course Code	Course Title	Hrs. /Week L: T: P	Credits	Preferred Semester
1	HSMC 101	English	2:0:2	3	II
2	HSMC 301	To be selected by	3:0:0	3	V
3	HSMC 302	Individual Institutions	3:0:0	3	VI
4	HSMC 401		3:0:0	3	VII
		Total		12	

MANDATORY COURSES

Sr. No.	Course Code	Course Title	Credits	Preferred Semesters
1	MC	[Environmental Sciences, Induction Program, NSS/NCC]	Nil	III, IV
		Total		0

PROFESSIONAL CORE COURSES [ELECTRICAL ENGINEERING]

Sr. No.	Course Code	Course Title	Hrs. /Week L: T: P	Credits	Preferred Semester
1	PCC-EE01	Electrical Circuit Analysis	3:1:0	4	III
2	PCC-EE02	Analog Electronics	3:0:0	3	III
3	PCC-EE03	Analog Electronics Laboratory	0:0:2	1	III
4	PCC-EE04	Electrical Machines – I	3:0:0	3	III
5	PCC-EE05	Electrical Machines Laboratory - I	0:0:2	1	III
6	PCC-EE06	Electromagnetic Fields	3:1:0	4	III
7	PCC-EE07	Digital Electronics	3:0:0	3	IV
8	PCC-EE08	Digital Electronics Laboratory	0:0:2	1	IV
9	PCC-EE09	Electrical Machines – II	3:0:0	3	IV
10	PCC-EE10	Electrical Machines Laboratory - II	0:0:2	1	IV
11	PCC-EE11	Power Electronics	3:0:0	3	IV
12	PCC-EE12	Power Electronics Laboratory	0:0:2	1	IV
13	PCC-EE13	Signals and Systems	2:1:0	3	IV
14	PCC-EE14	Power Systems -I	3:0:0	3	V
15	PCC-EE15	Power Systems Laboratory -I	0:0:2	1	V
16	PCC-EE16	Control Systems	3:0:0	3	V
17	PCC-EE17	Control Systems Laboratory	0:0:2	1	V
18	PCC-EE18	Microprocessors	3:0:0	3	V
19	PCC-EE19	Microprocessors Laboratory	0:0:2	1	V
20	PCC-EE20	Power Systems - II	3:0:0	3	VI
21	PCC-EE21	Power Systems Laboratory - II	0:0:2	1	VI
22	PCC-EE22	Measurements and Instrumentation Lab	2:0:2	3	VI
23	PCC-EE23	Electronic Design Laboratory	1:0:4	3	VI
		Total		53	

PROFESSIONAL ELECTIVE COURSES [ELECTRICAL ENGINEERING]

Sr. No.	Course Code	Course Title	Hrs. /Week L: T: P	Credits	Preferred Semester
1	PEC-EE01	Wind and Solar Energy Systems	3:0:0	3	VII onwards
2	PEC-EE02	Line Commutated and Active Rectifiers	3:0:0	3	VI onwards
3	PEC-EE03	Electrical Drives	3:0:0	3	VI onwards
4	PEC-EE04	Electrical and Hybrid Vehicles	3:0:0	3	VII onwards
5	PEC-EE05	Electrical Machine Design	3:0:0	3	V onwards
6	PEC-EE06	Power System Protection	3:0:0	3	VII onwards
7	PEC-EE07	HVDC Transmission Systems	3:0:0	3	VII onwards
8	PEC-EE08	Power Quality and FACTS	3:0:0	3	VII onwards
9	PEC-EE09	High Voltage Engineering	3:0:0	3	VI onwards
10	PEC-EE10	Electrical Energy Conservation and Auditing	3:0:0	3	VI onwards
11	PEC-EE11	Industrial Electrical Systems	3:0:0	3	VI onwards
12	PEC-EE12	Power System Dynamics and Control	3:0:0	3	VII onwards
13	PEC-EE13	Digital Control Systems	3:0:0	3	VI onwards
14	PEC-EE14	Digital Signal Processing	3:0:0	3	VI onwards
15	PEC-EE15	Computer Architecture	3:0:0	3	VI onwards
16	PEC-EE16	Electromagnetic Waves	3:0:0	3	VI onwards
17	PEC-EE17	Computational Electromagnetics	3:0:0	3	VI onwards
18	PEC-EE18	Control Systems Design	3:0:0	3	VI onwards
19	PEC-EE19	Advanced Electric Drives	3:0:0	3	VIII

OPEN ELECTIVE COURSES [ELECTRICAL ENGINEERING]

This is only an indicative list (Not Exhaustive)

Sl. No	Code No.	Subject	Credits
01	OEC-EE01	Electronic Devices	3
02	OEC-EE02	Data Structures and Algorithms	3
03	OEC-EE03	Analog and Digital Communication	3
04	OEC-EE04	Computer Networks	3
05	OEC-EE05	Embedded Systems	3

Sl. No	Code No.	Subject	Credits
06	OEC-EE06	VLSI circuits	3
07	OEC-EE07	Image Processing	3
08	OEC-EE08	Wavelet Transforms	3
09	OEC-EE09	Power Plant Engineering	3
10	OEC-EE10	Thermal and Fluid Engineering	3
11	OEC-EE11	Strength of Materials	3
12	OEC-EE12	Fluid Machinery	3
13	OEC-EE13	Automobile Engineering	3
14	OEC-EE14	Electrical Materials	3
15	OEC-EE15	Modern Manufacturing Processes	3
16	OEC-EE16	Internet of Things	3
17	OEC-EE17	Big Data Analysis	3

Section 3:

4 year Curriculum structure
Undergraduate Degree in Engineering & Technology

Branch / Course: Electrical Engineering
Total credits (4 year course) 158

I. **Mandatory 3-week Student Induction Program** (Please refer **Appendix-A** for guidelines and details.)

II. Semester-wise structure of curriculum

[L= Lecture, T = Tutorials, P = Practicals& C = Credits]

Semester I (First year]
Branch/Course : Electrical Engineering

Sl. No.	Course Code	Course Title	Hours per week			Total contact hours	Credits
			Lecture	Tutorial	Practical		
1	BSC 101	Mathematics – I (Calculus and Differential Equations)	3	1	0	4	4
2	BSC 102	Physics – I (Waves and Optics and Introduction to Quantum Mechanics)	3	1	3	7	5.5
3	HSMC 101	English	2	0	2	4	3
4	ESC 101	Programming for Problem Solving	3	0	4	7	5
		TOTAL CREDITS					17.5

Semester II (First year]
Branch/Course: Electrical Engineering

Sl. No.	Course Code	Course Title	Hours per week			Total contact hours	Credits
			Lecture	Tutorial	Practical		
1	BSC 103	Mathematics – II (Linear Algebra, Transform Calculus and Numerical Methods)	3	1	0	4	4
2	BSC 104	Chemistry – I	3	1	3	7	5.5
3	ESC 102	Workshop/Manufacturing Practices	1	0	4	5	3
4	ESC 103	Engineering Graphics	1	0	4	5	3
5	ESC 104	Basic Electrical Engineering	3	1	2	6	5
		TOTAL CREDITS					**20.5**

Semester III [Second year]
Branch/Course : Electrical Engineering

Sl. No	Course Code	Course Title	Hours per week			Total contact hours	Credits
			Lecture	Tutorial	Practical		
1	PCC-EE01	Electrical Circuit Analysis	3	1	0	4	4
2	PCC-EE02	Analog Electronics	3	0	0	3	3
3	PCC-EE03	Analog Electronics Laboratory	0	0	2	2	1
4	PCC-EE04	Electrical Machines – I	3	0	0	3	3
5	PCC-EE05	Electrical Machines Laboratory - I	0	0	2	2	1
6	PCC-EE06	Electromagnetic Fields	3	1	0	4	4
7	ESC 201	Engineering Mechanics	3	1	0	4	4
		TOTAL CREDITS					**20**
8	MC	Slot for MC					0

Semester IV [Second year]
Branch/Course: Electrical Engineering

Sl. No.	Course Code	Course Title	Hours per week			Total contact hours	Credits
			Lecture	Tutorial	Practical		
1	PCC-EE07	Digital Electronics	3	0	0	3	3
2	PCC-EE08	Digital Electronics Laboratory	0	0	2	2	1
3	PCC-EE09	Electrical Machines – II	3	0	0	3	3
4	PCC-EE10	Electrical Machines Laboratory - II	0	0	2	2	1
5	PCC-EE11	Power Electronics	3	0	0	3	3
6	PCC-EE12	Power Electronics Laboratory	0	0	2	2	1
7	PCC-EE13	Signals and Systems	2	1	0	3	3
8	BSC 201	Mathematics – III (Probability and Statistics)	3	1	0	4	4
9	BSC 202	Biology-I	2	1	0	3	3
		TOTAL CREDITS					**22**
10	MC	Slot for MC					0

Semester V [Third year]
Branch/Course: Electrical Engineering

Sl. No.	Course Code	Course Title	Hours per week			Total contact hours	Credits
			Lecture	Tutorial	Practical		
1	PCC-EE14	Power Systems–I (Apparatus and Modelling)	3	0	0	3	3
2	PCC-EE15	Power Systems Laboratory - I	0	0	2	2	1
3	PCC-EE16	Control Systems	3	0	0	3	3
4	PCC-EE17	Control Systems Laboratory	0	0	2	2	1
5	PCC-EE18	Microprocessors	3	0	0	3	3
6	PCC-EE19	Microprocessors Laboratory	0	0	2	2	1
7	PEC-EE01	Program Elective - 1	3	0	0	3	3
8	OEC-EE01	OE-1	3	0	0	3	3
9	HSMC 301	Slot for HS	3	0	0	3	3
		TOTAL CREDITS					**21**

Semester VI [Third year]
Branch/Course: Electrical Engineering

Sl. No.	Course Code	Course Title	Hours per week			Total contact hours	Credits
			Lecture	Tutorial	Practical		
1	PCC-EE20	Power Systems – II (Operation and Control)	3	0	0	3	3
2	PCC-EE21	Power Systems Laboratory - II	0	0	2	2	1
3	PCC-EE22	Measurements and Instrumentation Laboratory	2	0	2	3	3
4	PCC-EE23	Electronics Design Laboratory	1	0	4	5	3
5	PEC-EE02	Program Elective - 2	3	0	0	3	3
6	PEC-EE03	Program Elective - 3	3	0	0	3	3
7	OEC-EE02	OE-2	3	0	0	3	3
8	HSMC 302	Slot for HS	3	0	0	3	3
		TOTAL CREDITS					**22**
	PROJ-EE	Summer Internship	During Summer Vacations / Non-credit				

Semester VII [Fourth year]
Branch/Course: Electrical Engineering

Sl. No.	Course Code	Course Title	Hours per week			Total contact hours	Credits
			Lecture	Tutorial	Practical		
1	PEC-EE04	Program Elective -4	3	0	0	3	3
2	PEC-EE05	Program Elective -5	3	0	0	3	3
3	OEC-EE03	OE-3	3	0	0	3	3
4	OEC-EE04	OE-4	3	0	0	3	3
5	PROJ-EE01	Project Stage-I	0	0	6	6	3
6	HSMC 401	Slot for HS	3	0	0	3	3
		TOTAL CREDITS					**18**

Semester VIII [Fourth year]
Branch/Course: Electrical Engineering

Sl. No.	Course Code	Course Title	Hours per week			Total contact hours	Credits
			Lecture	Tutorial	Practical		
1	PEC-EE06	Program Elective -6	3	0	0	3	3
2	OEC-EE05	OE-5	3	0	0	3	3
3	OEC-EE06	OE-6	3	0	0	3	3
4	PROJ-EE02	Project Stage-II	0	0	16	16	8
		TOTAL CREDITS					**17**

TOTAL CREDITS – 158

CHAPTER 2

DETAILED 4-YEAR CURRICULUM CONTENTS

Undergraduate Degree in Engineering & Technology

Branch/Course: ELECTRICAL ENGINEERING

BASIC SCIENCE COURSES

BSC 101	Mathematics – I (Calculus and Differential Equations)	3L:1T:0P	4 credits

Contents

Module 1: Calculus (8 hours)

Evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions. Rolle's theorem, Mean value theorems, Taylor's and Maclaurin theorems with remainders; Indeterminate forms and L'Hospital's rule; Maxima and minima.

Module 2: Sequences and Series (7 hours)

Convergence of sequence and series, tests for convergence, power series, Taylor's series. Series for exponential, trigonometric and logarithmic functions; Fourier series: Half range sine and cosine series, Parseval's theorem.

Module 3: Multivariable Calculus: Differentiation (6 hours)

Limit, continuity and partial derivatives, directional derivatives, total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers; Gradient, curl and divergence.

Module 4: Multivariable Calculus: Integration (7 hours)

Multiple Integration: double and triple integrals (Cartesian and polar), change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: areas and volumes by (double integration) Center of mass and Gravity (constant and variable densities). Theorems of Green, Gauss and Stokes, orthogonal curvilinear coordinates, Simple applications involving cubes, sphere and rectangular parallelepipeds.

Module 5: First Order Ordinary Differential Equations (3 hours)

Exact, linear and Bernoulli's equations, Euler's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.

Module 6: Ordinary Differential Equations of Higher Order (6 hours)

Second order linear differential equations with variable coefficients, method of variation of parameters, Cauchy-Euler equation; Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties.

Module 7: Partial Differential Equations: First Order (3 hours)

First order partial differential equations, solutions of first order linear and non-linear PDEs.

Text / References:

1. G.B. Thomas and R.L. Finney, "Calculus and Analytic geometry", Pearson, 2002.

2. T. Veerarajan, "Engineering Mathematics", McGraw-Hill, New Delhi, 2008.
3. B. V. Ramana, "Higher Engineering Mathematics", McGraw Hill, New Delhi, 2010.
4. N.P. Bali and M. Goyal, "A text book of Engineering Mathematics", Laxmi Publications, 2010.
5. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 2000.
6. E. Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons, 2006.
7. W. E. Boyce and R. C. DiPrima, "Elementary Differential Equations and Boundary Value Problems", Wiley India, 2009.
8. S. L. Ross, "Differential Equations", Wiley India, 1984.
9. E. A. Coddington, "An Introduction to Ordinary Differential Equations", Prentice Hall India, 1995.
10. E. L. Ince, "Ordinary Differential Equations", Dover Publications, 1958.
11. G.F. Simmons and S.G. Krantz, "Differential Equations", McGraw Hill, 2007.

BSC 102	**Physics-I (Waves and Optics and Introduction to Quantum Mechanics)**	**3L:1T:3P**	**5.5 credits**

Module 1: Waves (3 hours)
Mechanical and electrical simple harmonic oscillators, damped harmonic oscillator, forced mechanical and electrical oscillators, impedance, steady state motion of forced damped harmonic oscillator

Module 2: Non-dispersive transverse and longitudinal waves (4 hours)
Transverse wave on a string, the wave equation on a string, Harmonic waves, reflection and transmission of waves at a boundary, impedance matching, standing waves and their Eigen frequencies, longitudinal waves and the wave equation for them, acoustics waves

Module 3: Light and Optics (3 hours)
Light as an electromagnetic wave and Fresnel equations, reflectance and transmittance, Brewster's angle, total internal reflection, and evanescent wave. Mirrors and lenses and optical instruments based on them

Module 4: Wave Optics (5 hours)
Huygens' principle, superposition of waves and interference of light by wavefront splitting and amplitude splitting; Young's double slit experiment, Newton's rings, Michelson interferometer, Mach Zehnder interferometer. Farunhofer diffraction from a single slit and a circular aperture, the Rayleigh criterion for limit of resolution and its application to vision; Diffraction gratings and their resolving power

Module 5: Lasers (5 hours)
Einstein's theory of matter radiation interaction and A and B coefficients; amplification of light by population inversion, different types of lasers: gas lasers (He-Ne, CO_2), solid-state lasers (ruby, Neodymium), dye lasers; Properties of laser beams: mono-chromaticity

Module 6: Introduction to Quantum Mechanics (5 hours)
Wave nature of Particles, Time-dependent and time-independent Schrodinger equation for wave function, Born interpretation, probability current, Expectation values, Free-particle wave function and wave-packets, Uncertainty principle.

Module 7: Solution of Wave Equation(6 hours)
Solution of stationary-state Schrodinger equation for one dimensional problems–particle in a box, particle in attractive delta-function potential, square-well potential, linear harmonic oscillator. Scattering from a potential barrier and tunneling; related examples like alpha-decay, field-ionization and scanning tunneling microscope, tunneling in semiconductor structures. Three-dimensional problems: particle in three dimensional box and related examples.

Module 8: Introduction to Solids and Semiconductors.(9 hours)
Free electron theory of metals, Fermi level, density of states in 1, 2 and 3 dimensions, Bloch's theorem for particles in a periodic potential, Kronig-Penney model and origin of energy bands.

Types of electronic materials: metals, semiconductors, and insulators. Intrinsic and extrinsic semiconductors, Dependence of Fermi level on carrier-concentration and temperature (equilibrium carrier statistics), Carrier generation and recombination, Carrier transport: diffusion and drift, p -n junction.

Text / References:
1. I. G. Main, "Vibrations and waves in physics", Cambridge University Press, 1993.
2. H. J. Pain, "The physics of vibrations and waves", Wiley, 2006.
3. E. Hecht, "Optics", Pearson Education, 2008.
4. A. Ghatak, "Optics", McGraw Hill Education, 2012.
5. O. Svelto, "Principles of Lasers", Springer Science & Business Media, 2010.
6. D. J. Griffiths, "Quantum mechanics", Pearson Education, 2014.
7. R. Robinett, "Quantum Mechanics", OUP Oxford, 2006.
8. D. McQuarrie, "Quantum Chemistry", University Science Books, 2007.
9. D. A. Neamen, "Semiconductor Physics and Devices", Times Mirror High Education Group, Chicago, 1997.
10. E.S. Yang, "Microelectronic Devices", McGraw Hill, Singapore, 1988.
11. B.G. Streetman, "Solid State Electronic Devices", Prentice Hall of India, 1995.

BSC 103	**Mathematics-II (Linear Algebra, Transform Calculus and Numerical Methods)**	**3L:1T:0P**	**4 credits**

Module 1: Matrices (10 hours)
Algebra of matrices, Inverse and rank of a matrix, rank-nullity theorem; System of linear equations; Symmetric, skew-symmetric and orthogonal matrices; Determinants; Eigenvalues and eigenvectors; Diagonalization of matrices; Cayley-Hamilton Theorem, Orthogonal transformation and quadratic to canonical forms.

Module 2: Numerical Methods-I (10 hours)
Solution of polynomial and transcendental equations – Bisection method, Newton-Raphson method and Regula-Falsi method. Finite differences, Interpolation using Newton's forward and backward difference formulae. Central difference interpolation: Gauss's forward and backward formulae. Numerical integration: Trapezoidal rule and Simpson's 1/3rd and 3/8 rules.

Module 3: Numerical Methods-II (10 hours)
Ordinary differential equations: Taylor's series, Euler and modified Euler's methods. Runge-Kutta method of fourth order for solving first and second order equations. Milne's and Adam's predicator-corrector methods. Partial differential equations: Finite difference solution two dimensional Laplace equation and Poisson equation, Implicit and explicit methods for one dimensional heat equation (Bender-Schmidt and Crank-Nicholson methods), Finite difference explicit method for wave equation.

Module 4: Transform Calculus (10 hours)
Laplace Transform, Properties of Laplace Transform, Laplace transform of periodic functions. Finding inverse Laplace transform by different methods, convolution theorem. Evaluation of integrals by Laplace transform, solving ODEs and PDEs by Laplace Transform method. Fourier transforms.

Text / References:

1. D. Poole, "Linear Algebra: A Modern Introduction", Brooks/Cole, 2005.
2. N.P. Bali and M. Goyal, "A text book of Engineering Mathematics", Laxmi Publications, 2008.
3. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 2010.
4. V. Krishnamurthy, V. P. Mainra and J. L. Arora, "An introduction to Linear Algebra", Affiliated East-West press, 2005.

BSC 104	Chemistry -I	3L:1T:3P	5.5 credits

Contents

Module 1: Atomic and molecular structure (12 hours)

Schrodinger equation. Particle in a box solutions and their applications for conjugated molecules and nanoparticles. Forms of the hydrogen atom wave functions and the plots of these functions to explore their spatial variations. Molecular orbitals of diatomic molecules and plots of the multi-centre orbitals. Equations for atomic and molecular orbitals. Energy level diagrams of diatomics. Pi-molecular orbitals of butadiene and benzene and aromaticity. Crystal field theory and the energy level diagrams for transition metal ions and their magnetic properties. Band structure of solids and the role of doping on band structures.

Module 2: Spectroscopic techniques and applications (8 hours)

Principles of spectroscopy and selection rules. Electronic spectroscopy. Fluorescence and its applications in medicine. Vibrational and rotational spectroscopy of diatomic molecules. Applications. Nuclear magnetic resonance and magnetic resonance imaging, surface characterization techniques. Diffraction and scattering.

Module 3: Intermolecular forces and potential energy surfaces (4 hours)

Ionic, dipolar and van Der Waals interactions. Equations of state of real gases and critical phenomena. Potential energy surfaces of H_3, H_2F and HCN and trajectories on these surfaces.

Module 4: Use of free energy in chemical equilibria (6 hours)

Thermodynamic functions: energy, entropy and free energy. Estimations of entropy and free energies. Free energy and emf. Cell potentials, the Nernst equation and applications. Acid base, oxidation reduction and solubility equilibria. Water chemistry. Corrosion. Use of free energy considerations in metallurgy through Ellingham diagrams.

Module 5: Periodic properties (4 hours)

Effective nuclear charge, penetration of orbitals, variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes, ionization energies, electron affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases, molecular geometries

Module 6: Stereochemistry (4 hours)

Representations of 3 dimensional structures, structural isomers and stereoisomers, configurations and symmetry and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis. Isomerism in transitional metal compounds.

Module 7: Organic reactions and synthesis of a drug molecule (4 hours)

Introduction to reactions involving substitution, addition, elimination, oxidation, reduction, cyclization and ring openings. Synthesis of a commonly used drug molecule.

Text / References:

1. B. H. Mahan, "University chemistry", Addison-Wesley Publishing Company, 1975.
2. M. J. Sienko and R. A. Plane, "Chemistry: Principles and Applications", McGraw Hill International, 1974.
3. C. N. Banwell, "Fundamentals of Molecular Spectroscopy", McGraw Hill Education, 1994.
4. B. L. Tembe, Kamaluddin and M. S. Krishnan, "Engineering Chemistry" (NPTEL).
5. K.P.C. Volhardt and N. E. Schore, "Organic Chemistry: Structure and Function" Freeman, 2010.

Course Outcomes

The concepts developed in this course will aid in quantification of several concepts in chemistry that have been introduced at the 10+2 levels in schools. Technology is being increasingly based on the electronic, atomic and molecular level modifications.

Quantum theory is more than 100 years old and to understand phenomena at nanometer levels, one has to base the description of all chemical processes at molecular levels. The course will enable the student to:

- Analyse microscopic chemistry in terms of atomic and molecular orbitals and intermolecular forces.
- Rationalise bulk properties and processes using thermodynamic considerations.
- Distinguish the ranges of the electromagnetic spectrum used for exciting different molecular energy levels in various spectroscopic techniques
- Rationalise periodic properties such as ionization potential, electronegativity, oxidation states and electronegativity.
- List major chemical reactions that are used in the synthesis of molecules.

Chemistry Laboratory (0:0:3 - 1.5 credits)

Choice of 10-12 experiments from the following

1. Determination of surface tension and viscosity
2. Thin layer chromatography
3. Ion exchange column for removal of hardness of water
4. Determination of chloride content of water
5. Colligative properties using freezing point depression
6. Determination of the rate constant of a reaction
7. Determination of cell constant and conductance of solutions
8. Potentiometry - determination of redox potentials and emfs.
9. Synthesis of a polymer/drug
10. Saponification/acid value of an oil
11. Chemical analysis of a salt
12. Lattice structures and packing of spheres
13. Models of potential energy surfaces
14. Chemical oscillations- Iodine clock reaction
15. Determination of the partition coefficient of a substance between two immiscible liquids
16. Adsorption of acetic acid by charcoal
17. Use of the capillary viscosimeters to the demonstrate of the isoelectric point as the pH of minimum viscosity for gelatin sols and/or coagulation of the white part of egg

Laboratory Outcomes

- The chemistry laboratory course will consist of experiments illustrating the principles of chemistry relevant to the study of science and engineering. The students will learn to:
- Estimate rate constants of reactions from concentration of reactants/products as a function of time
- Measure molecular/system properties such as surface tension, viscosity, conductance of solutions, redox potentials, chloride content of water, etc
- Synthesize a small drug molecule and analyse a salt sample

BSC 201	**Mathematics-III (Probability and Statistics)**	**3L:1T:0P**	**4 credits**

Module 1: Basic Probability (12 hours)
Probability spaces, conditional probability, independence; Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality.

Module 2: Continuous Probability Distributions (4 hours)
Continuous random variables and their properties, distribution functions and densities, normal, exponential and gamma densities.

Module 3: Bivariate Distributions (4 hours)
Bivariate distributions and their properties, distribution of sums and quotients, conditional densities, Bayes' rule.

Module 4: Basic Statistics (8 hours)
Measures of Central tendency: Moments, skewness and Kurtosis - Probability distributions: Binomial, Poisson and Normal - evaluation of statistical parameters for these three distributions, Correlation and regression – Rank correlation.

Module 5: Applied Statistics (8 hours)
Curve fitting by the method of least squares- fitting of straight lines, second degree parabolas and more general curves. Test of significance: Large sample test for single proportion, difference of proportions, single mean, difference of means, and difference of standard deviations.

Module 6: Small samples (4 hours)
Test for single mean, difference of means and correlation coefficients, test for ratio of variances - Chi-square test for goodness of fit and independence of attributes.

Text / References:

1. E. Kreyszig, “Advanced Engineering Mathematics”, John Wiley & Sons, 2006.
2. P. G. Hoel, S. C. Port and C. J. Stone, “Introduction to Probability Theory”, Universal Book Stall, 2003.
3. S. Ross, “A First Course in Probability”, Pearson Education India, 2002.
4. W. Feller, “An Introduction to Probability Theory and its Applications”, Vol. 1, Wiley, 1968.
5. N.P. Bali and M. Goyal, “A text book of Engineering Mathematics”, Laxmi Publications, 2010.
6. B.S. Grewal, “Higher Engineering Mathematics”, Khanna Publishers, 2000.
7. T. Veerarajan, “Engineering Mathematics”, Tata McGraw-Hill, New Delhi, 2010.

BSC 202	Biology-I	2L:1T:0P	3 credits

Module 1: Introduction (2 hours)
Purpose: To convey that Biology is as important a scientific discipline as Mathematics, Physics and Chemistry. Bring out the fundamental differences between science and engineering by drawing a comparison between eye and camera, Bird flying and aircraft. Mention the most exciting aspect of biology as an independent scientific discipline. Why we need to study biology? Discuss how biological observations of 18th Century that lead to major discoveries. Examples from Brownian motion and the origin of thermodynamics by referring to the original observation of Robert Brown and Julius Mayor. These examples will highlight the fundamental importance of observations in any scientific inquiry.

Module 2: Classification (3 hours)
Purpose: To convey that classification *per se* is not what biology is all about. The underlying criterion, such as morphological, biochemical or ecological be highlighted. Hierarchy of life forms at phenomenological level. A common thread weaves this hierarchy Classification. Discuss classification based on (a) cellularity- Unicellular or multicellular (b) ultrastructure- prokaryotes or eucaryotes. (c) energy and Carbon utilization -Autotrophs, heterotrophs, lithotropes (d) Ammonia excretion – aminotelic, uricotelic, ureotelic (e) Habitata- acquatic or terrestrial (e) Molecular taxonomy- three major kingdoms of life. A given organism can come under different category based on classification. Model organisms for the study of biology come from different groups. E.coli, S.cerevisiae, D. Melanogaster, C. elegance, A. Thaliana, M. musculus

Module 3: Genetics (4 hours)
Purpose: To convey that “Genetics is to biology what Newton’s laws are to Physical Sciences”. Mendel’s laws, Concept of segregation and independent assortment. Concept of allele. Gene mapping, Gene interaction, Epistasis. Meiosis and Mitosis be taught as a part of genetics. Emphasis to be give not to the mechanics of cell division nor the phases but how genetic material passes from parent to offspring. Concepts of recessiveness and dominance. Concept of mapping of phenotype to genes. Discuss about the single gene disorders in humans. Discuss the concept of complementation using human genetics.

Module 4: Biomolecules (4 hours)
Purpose: To convey that all forms of life has the same building blocks and yet the manifestations are as diverse as one can imagine. Molecules of life. In this context discuss monomeric units and polymeric structures. Discuss about sugars, starch and cellulose. Amino acids and proteins. Nucleotides and DNA/RNA. Two carbon units and lipids.

Module 5: Enzymes (4 Hours)
Purpose: To convey that without catalysis life would not have existed on earth.
Enzymology: How to monitor enzyme catalysed reactions. How does an enzyme catalyse reactions? Enzyme classification. Mechanism of enzyme action. Discuss at least two examples. Enzyme kinetics and kinetic parameters. Why should we know these parameters to understand biology? RNA catalysis.

Module 6: Information Transfer (4 hours)
Purpose: The molecular basis of coding and decoding genetic information is universal. Molecular basis of information transfer. DNA as a genetic material. Hierarchy of DNA structure- from single stranded to double helix to nucleosomes. Concept of genetic code. Universality and degeneracy of genetic code. Define gene in terms of complementation and recombination.

Module 7: Macromolecular analysis (5 hours)
Purpose: To analyse biological processes at the reductionistic level. Proteins- structure and function. Hierarch in protein structure. Primary secondary, tertiary and quaternary structure. Proteins as enzymes, transporters, receptors and structural elements.

Module 8: Metabolism (4 hours)
Purpose: The fundamental principles of energy transactions are the same in physical and biological world. Thermodynamics as applied to biological systems. Exothermic and endothermic versus endergonic and exergonic reactions. Concept of K_{eq} and its relation to standard free energy. Spontaneity. ATP as an energy currency. This should include the breakdown of glucose to CO_2 + H_2O (Glycolysis and Krebs cycle) and synthesis of glucose from CO_2 and H_2O (Photosynthesis). Energy yielding and energy consuming reactions. Concept of Energy charge.

Module 9. Microbiology (3 hours)
Concept of single celled organisms. Concept of species and strains. Identification and classification of microorganisms. Microscopy. Ecological aspects of single celled organisms. Sterilization and media compositions. Growth kinetics.

Text / References:
1. N. A. Campbell, J. B. Reece, L. Urry, M. L. Cain and S. A. Wasserman, “Biology: A global approach”, Pearson Education Ltd, 2014.
2. E. E. Conn, P. K. Stumpf, G. Bruening and R. H. Doi, “Outlines of Biochemistry”, John Wiley and Sons, 2009.
3. D. L. Nelson and M. M. Cox, “Principles of Biochemistry”, W.H. Freeman and Company, 2012.
4. G. S. Stent and R. Calendar, “Molecular Genetics”, Freeman and company, 1978.
5. L. M. Prescott, J. P. Harley and C. A. Klein, “Microbiology”, McGraw Hill Higher Education, 2005.

Course Outcomes

After studying the course, the student will be able to:

- Describe how biological observations of 18th Century that lead to major discoveries.
- Convey that classification *per se* is not what biology is all about but highlight the underlying criteria, such as morphological, biochemical and ecological
- Highlight the concepts of recessiveness and dominance during the passage of genetic material from parent to offspring
- Convey that all forms of life have the same building blocks and yet the manifestations are as diverse as one can imagine
- Classify enzymes and distinguish between different mechanisms of enzyme action.
- Identify DNA as a genetic material in the molecular basis of information transfer.
- Analyse biological processes at the reductionistic level
- Apply thermodynamic principles to biological systems.
- Identify and classify microorganisms.
