

Model Curriculum for UG Degree Course in Biotechnology

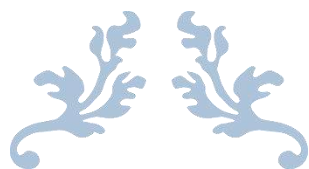
2020



ALL INDIA COUNCIL FOR TECHNICAL EDUCATION

Nelson Mandela Marg, Vasant Kunj, New Delhi 110070

www.aicte-india.org



MODEL CURRICULUM FOR UNDERGRADUATE COURSE IN BIOTECHNOLOGY



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(भारत सरकार का एक सांविधिक निकाय)

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ALL INDIA COUNCIL FOR TECHNICAL EDUCATION

(A Statutory Body of the Govt. of India)

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MESSAGE

The quality of technical education depends on many factors but largely on outcome-based socially and industrially relevant curriculum, good quality motivated faculty, teaching-learning processes, effective industry internship and evaluation of students based on desired outcomes. Therefore, in a bid to improve the quality, it was imperative that a revised AICTE model curriculum be prepared by best experts from academia and industry. AICTE constituted a team of experts to prepare a model curriculum for the UG Degree Course in Biotechnology. Just as for other UG, Diploma and PG level in Engineering, MBA, PGDM, Architecture, etc., keeping in view the latest industry trends and market requirements.

In this Model Curriculum, the number of credits has been reduced to 160. It is comprising of basic science and engineering courses, having a focus on fundamentals, significant discipline level courses and ample electives both from the disciplines and cross-disciplines, including emerging areas. Internships have been embedded in summer breaks to make the student understand the industry requirements, have adequate hands-on experience and take-up project work relevant to the industry in their final year. These features, it is expected will allow students to develop a problem-solving approach to face the challenges in the future.

As a major initiative by AICTE, a three-week mandatory Student Induction Program has been designed and positioned at the beginning of the course. The idea behind this is to make the students feel comfortable in their new environment, open them up, set a healthy daily routine, create bonding in the batch as well as between faculty and students, develop awareness, sensitivity and understanding of the self, people around them, society at large, and nature.

AICTE places on record, special thanks to Prof. Sudip Kumar Ghosh, Prof. Mrutyunjay Suar, Dr. Shriram Raghavan and Dr. Neel Sarovar Bhavesh and other experts involved in the development of this curriculum. We are sure that this Model Curriculum will help enhance employability and also prompt youngsters to become job creators, considering the introduction of courses like 'Entrepreneurship and Startups', 'IPR & Regulatory'.

We strongly urge the institutions/universities/boards of technical education in India to adopt this Model Curriculum at the earliest. This is a suggestive curriculum which the concerned agencies should build on and exercise flexibility in the readjustment of courses/credits within the overall 160 credits.

(Prof. Anil D. Sahasrabudhe)

PREFACE

Taking cognizance of growing concern about the quality of technical education in India, AICTE in its 49th council meeting held on 14.03.2017 approved a package of measures for improving the quality of technical education - Revision of Curriculum, Mandatory Internship, and Student Induction Program among the few.

Having developed Model Curricula for major branches of Engineering & Technology, and realizing a need for the same for Biotechnology, AICTE constituted a committee of experts. During the development of the curriculum, the employability and employment opportunities for graduates were kept in mind.

AICTE has introduced mandatory internships in the new curriculum which will equip the students with practical understanding and training about industry practices. Students are encouraged to undergo a course on 'Entrepreneurship and Start-ups' and also to work on bio-start-ups as a part of their final year project. A path-breaking intervention is the 3-Week Student Induction Program for seamless initiation of students into professional courses.

Other salient features of this model curriculum are:

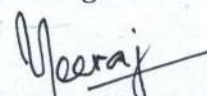
- Reduced the number of credits to 160.
- Well defined learning objectives & outcomes for each course.
- Inclusion of courses on socially relevant topics and sports.
- Built-in flexibility for professional elective and open elective courses.
- A suggestive list of Professional Electives and Open Electives.
- Balanced weightage of theory and practical (in terms of contact hours).
- A list of experiments for each lab course.

The Curriculum has been designed to comprehensively address the needs of the industry, considering evolving technological trends in biotechnology and its implications for the engineering workforce. A suggestive list of Professional Electives has been drawn and provided separately as Appendix I; similarly, Appendix II on Open Electives has been provided.

I gratefully acknowledge the time and efforts of the members of this curriculum development committee namely Prof. Sudip Kumar Ghosh from IIT Kharagpur, Prof. Mrutyunjay Suar from KIIT University, Dr. Shriram Raghavan from Jananom Pvt. Ltd. and Dr. Neel Sarovar Bhavesh from ICGEB, New Delhi. Inputs received from well-known experts in Biotechnology like Prof. Suneel Kateria, Prof. Vimlesh Kumar, Prof. Ritu Kulsherstha, Prof. Sourabh Ghosh, Dr. Dhiraj Kumar, Prof. Manu Agarwal, Prof. Yasha Hasija and Dr. Amarnath Chatterjee are also acknowledged.

Special thanks to Prof. Anil D. Sahasrabudhe, Chairman; Prof. M.P. Poonia, Vice-Chairman; and Prof. Rajive Kumar, Member Secretary, AICTE who all have been instrumental and encouraging throughout the process of development of this model curriculum.

I record my appreciation for the efforts and dedication of my colleagues – Dr. Neetu Bhagat, Deputy Director (P&AP); Shri Manoj Singh, Asst. Director (P&AP); Shri Vipin Kumar, Assistant Director; Mr. Dharmesh Kumar Dewangan, Young Professional (P&AP) and other office staff of AICTE.



(Dr. Neeraj Saxena)

Adviser – II; P&AP Bureau

All India Council for Technical Education

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**GENERAL COURSE STRUCTURE
&
THEME**

GENERAL COURSE STRUCTURE & THEME

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	0.5 Credit
2 Hours Practical (P) per week	1 Credit

B. Range of Credits: 160 credits needs to be covered by a student to be eligible to get an Undergraduate Degree in Biotechnology.

C. Structure of Undergraduate Biotechnology Program: The structure of Biotechnology program shall have essentially the following categories of courses with the breakup of credits as given:

S. No.	Code	Category	Suggested Breakup of Credits (Total 160)
1	HS	Humanities and Social Sciences including Management, Regulatory courses.	12*
2	BSC	Basic Science courses.	19*
3	ESC	Engineering Science Courses	16*
4	BS	Biological Science courses including laboratory	16*
5	PC	Professional Core Courses	43*
6	PE	Professional Elective Courses	18*
7	OS	Open Subjects - Electives from cross discipline technical and / or emerging subjects	18*
8	PS	Project work, seminar and internship in industry or elsewhere.	18*
9	AU	Audit Courses	(non-credit)
		TOTAL	160*

*: Minor variation is allowed.

D. Course Code and Definitions:

Course code	Definitions
L	Lecture
T	Tutorial
P	Practical
C	Credit
C.A.	Continuous Assessment
E.S.A.	End Semester Assessment
HS	Humanities & Social Sciences Courses
BSC	Basic Science Courses
ESC	Engineering Science Courses
BS	Biological Science Courses

PC	Program Core Courses
PE	Program Elective Courses
OS	Open Subjects
PS	Project Work, Seminar, Internship
AU	Audit Courses

E. Course Level Coding Scheme: Three-digit number (odd numbers are for the odd semester courses and even numbers are for even semester courses) used as suffix with the Course Code for identifying the level of the course e.g.

101, 102 ... etc. for first year

201, 202 Etc. for second year

301, 302 ... for third year

F. Category-wise Courses

HUMANITIES & SOCIAL SCIENCES COURSES [HS]

(i) Number of Humanities & Social Sciences Courses: 5

(ii) Credits: 12

S. No.	Course Code	Name	Hours per week			Semester	Credits
			L	T	P		
1	HS102	English	2	0	2	II	3
2	HS201	Effective Technical Communication	3	0	0	III	3
3	HS202	Engineering Economics	2	0	0	IV	2
4	HS301	Entrepreneurships & Startups	1	1	0	V	2
5	HS401	Intellectual Property Rights (IPR) & Regulatory	1	1	0	VII	2
TOTAL							12

BASIC SCIENCES COURSES [BSC]

(i) Number of Basic Sciences Courses: 4

(ii) Credits: 19

S. No.	Course Code	Name	Hours per week			Semester	Credits
			L	T	P		
1	BSC101	Physics-I	3	1	3	I	5.5
2	BSC103	Mathematics-I	3	1	0	I	4
3	BSC102	Chemistry-I	3	1	3	II	5.5
4	BSC104	Mathematics-II	3	1	0	II	4
TOTAL							19

ENGINEERING SCIENCES COURSES [ESC]

(i) Number of Engineering Sciences Courses: 4

(ii) Credits: 16

S. No.	Course Code	Name	Hours per week			Semester	Credits
			L	T	P		
1	ESC101	Basic Electrical Engineering	3	1	2	I	5
2	ESC103	Engineering Graphics & Design	1	0	4	I	3
3	ESC102	Programming for Problem Solving	3	0	4	II	5
4	ESC104	Workshop/Manufacturing Practices	1	0	4	II	3
TOTAL							16

BIOLOGICAL SCIENCES COURSES [BS]

(i) Number of Biological Sciences Courses: 6

(ii) Credits: 16

S. No.	Course Code	Name	Hours per week			Semester	Credits
			L	T	P		
1	BS201	Biochemistry	2	0	2	III	3
2	BS203	Microbiology	2	0	2	III	3
3	BS205	Genetics	2	0	2	III	3
4	BS207	Biophysics	2	0	0	III	2
5	BS209	Cell & Molecular Biology	2	0	2	III	3
6	BS211	Plant Biology	1	0	2	III	2
TOTAL							16

PROFESSIONAL CORE COURSES [PC]

(i) Number of Professional Core Courses: 14

(ii) Credits: 43

S. No.	Course Code	Name	Hours per week			Semester	Credits
			L	T	P		
1	PC202	Bioprocess engineering	2	0	2	IV	3
2	PC204	Green Biotechnology and Pollution Abatement	2	0	0	IV	2
3	PC206	Immunology & Immunotechnology	2	0	2	IV	3
4	PC208	rDNA technology	2	0	2	IV	3
5	PC210	Structural Biology	2	1	0	IV	3

6	PC212	Bioinformatics & Computational Biology	2	0	2	IV	3
7	PC301	Metabolic Engineering	2	0	2	V	3
8	PC303	Analytical Techniques	2	0	2	V	3
9	PC305	Cheminformatics & Medicinal Chemistry	2	0	2	V	3
10	PC307	Good Manufacturing and Laboratory Practice	2	1	0	V	3
11	PC302	Bioseparation Engineering	2	0	2	VI	3
12	PC304	Synthetic & Systems Biology	3	0	2	VI	4
13	PC306	Animal & Plant Biotechnology	2	0	4	VI	4
14	PC401	Data Analysis and Simulations	2	0	2	VII	3
TOTAL							43

PROFESSIONAL ELECTIVE COURSES [PE] *

(i) Number of Professional Elective Courses: $4 \times 3 = 12$

(ii) Credits: 18

S. No.	Course Code	Name	Hours per week			Semester	Credits
			L	T	P		
1	PE301	Big Data Analytics	3	1	2	V	5
2	PE303	Genome Editing	3	1	2		
3	PE305	Biosimilars Technology	3	1	2		
4	PE302	Machine Learning	3	1	2	VI	5
5	PE304	Waste Management & Upcycling	3	1	2		
6	PE306	Stem-Cell Technology	3	1	2		
7	PE401	Gene Expression and Transgenics	3	1	2	VII	5
8	PE403	Rational Drug Discovery	3	1	2		
9	PE405	State-of-the-art Imaging	3	1	2		
10	PE407	Precision Medicine & Wellness	2	1	0	VII	3
11	PE409	Tissue Engineering	2	1	0		
12	PE411	Nano Biotechnology	2	1	0		
TOTAL							18

***Students have to select one from each group of I (PE301, PE303, PE305), II (PE302, PE304, PE306), III (PE401, PE403, PE405), IV (PE407, PE409, PE411)**

OPEN SUBJECTS [OS]*

(i) Number of Open Subjects: $3 \times 4 + 1 \times 2 = 14$

(ii) Credits: 18

S. No.	Course Code	Name	Hours per week			Semester	Credits
			L	T	P		
1	OS301	3D Printing & Design	3	1	2	V	5
2	OS303	Internet of Things	3	1	2		
3	OS305	Image Processing	3	1	2		
4	OS307	Biomaterials	3	1	2		
5	OS302	Artificial Intelligence	3	1	2	VI	5
6	OS304	Quantum Computing	3	1	2		
7	OS306	Cyber Security	3	1	2		
8	OS308	Design Thinking	3	1	2		
9	OS401	Robotics	3	1	2	VII	5
10	OS403	Virtual Reality	3	1	2		
11	OS405	Data Sciences	3	1	2		
12	OS407	Food and Nutrition Technology	3	1	2		
13	OS409	Block Chain	2	1	0	VII	3
14	OS411	Bioterrorism and National Security	2	1	0		
TOTAL							18

***Students have to select one from each group of I (OS301, OS303, OS305, OS307), II (OS302, OS304, OS306, OS308), III (OS401, OS403, OS405, OS407), IV (OS409, OS411)**

PROJECT WORK, SEMINAR, INTERNSHIP [PS]

- (i) Number of Open Subjects: 6
(ii) Credits: 18

S. No.	Code No	Name	Hours per week			Semester	Credits
			L	T	P		
1	PS201	Technical Seminar	0	0	2	III	1
2	PS202	Comprehensive <i>viva voce</i>	0	0	2	IV	1
3	PS301	Summer Internship-I	0	0	4	V	2
4	PS401	Project-I	0	0	4	VII	2
5	PS403	Summer Internship-II	0	0	6	VII	3
6	PS402	Project-II (Biotech Industrial or Biotech In-house Project or Bio-Entrepreneurship)	0	0	18	VIII	9
TOTAL							18

AUDIT COURSES [AU]

Note: These are mandatory non-credit courses.

S. No.	Code No	Name	Hours per week			Semester	Credits
			L	T	P		
1	AU102	Sports and Yoga	2	0	0	II	0
2	AU202	Environmental Science	2	0	0	IV	0
3	AU301	Indian Constitution	2	0	0	V	0
TOTAL							0

G. Induction Program

Please refer Appendix III for guidelines.

The Essence and Details of Induction program can also be understood from the 'Detailed Guide on Student Induction program', as available on AICTE Portal.

(<https://www.aicteindia.org/sites/default/files/Detailed%20Guide%20on%20Student%20Induction%20program.pdf>).

Induction Program (Mandatory)	Three-week Duration
Induction program for students to be offered right at the start of the first year.	<ul style="list-style-type: none"> ● Physical activity ● Creative Arts ● Universal Human Values ● Literary ● Proficiency Modules ● Lectures by Eminent People ● Visits to local Areas ● Familiarization to Dept./Branch & Innovations

H. Mandatory Visits/ Workshop/Expert Lectures:

- a. It is mandatory to arrange one industrial visit every semester.
- b. It is mandatory to conduct a One-week workshop during the winter break after fifth semester on professional/ industry/ entrepreneurial orientation.
- c. It is mandatory to organize at least one expert lecture per by inviting resource persons from Biotechnology related industry.

I. Evaluation Scheme (Suggestive only):

- a. **For Theory & Practical Courses:** The weightage of Continuous Assessment (C.A.) and End Semester Assessment (E.S.A.) is mentioned for every subject. If not mentioned anywhere, then Continuous Assessment may be given 40% weightage and End Semester may be given 60% weightage. The student has to obtain at least 40% marks individually both in internal assessment and end semester exams to pass.

- b. **For Internship / Projects / Seminar etc.:** Evaluation is based on work done, quality of report, performance in viva-voce, presentation etc.

Note: The Continuous Assessment (C.A.) is based on the student's performance in mid semester tests (two best out of three), quizzes, assignments, class performance, attendance, viva-voce in practical, lab record etc.

- J. **Mapping of Marks to Grades:** Each course (Theory/Practical) is to be assigned 100 marks, irrespective of the number of credits, and the mapping of marks to grades may be done as per the following table:

Range of Marks	Assigned Grade
91-100	AA/A ⁺
81-90	AB/A
71-80	BB/B ⁺
61-70	BC/B
51-60	CC/C ⁺
46-50	CD/C
40-45	DD/D
< 40	FF/F (Fail due to less marks)
-	(Fail due to shortage of attendance and therefore, to repeat the course)

SEMESTER WISE CREDIT DISTRIBUTION

SEMESTER I

S. No.	Course Code	Course Title	L	T	P	Credit
3 WEEKS COMPULSORY INDUCTION PROGRAM						
1	BSC101	Physics-I	3	1	3	5.5
2	BSC103	Mathematics-I	3	1	0	4
3	ESC101	Basic Electrical Engineering	3	1	2	5
4	ESC103	Engineering Graphics & Design	1	0	4	3
TOTAL			10	3	9	17.5

SEMESTER II

S. No.	Course Code	Course Title	L	T	P	Credit
1	BSC102	Chemistry-I	3	1	3	5.5
2	BSC104	Mathematics-II	3	1	0	4
3	ESC102	Programming for Problem Solving	3	0	4	5
4	HS102	English	2	0	2	3
5	ESC104	Workshop/Manufacturing Practices	1	0	4	3
6	AU102	Sports and Yoga	2 [^]	0	0	0
TOTAL			12+2[^]	2	13	20.5

Note: [^] represents related to Audit Course.

SEMESTER III

S. No.	Course Code	Course Title	L	T	P	C	Contact Hours Per Week	Max. Marks	
								C.A	E.S.A
1	HS201	Effective Technical Communication	3	0	0	3	3	25	75
2	BS201	Biochemistry	2	0	2	3	4	25	75
3	BS203	Microbiology	2	0	2	3	4	25	75
4	BS205	Genetics	2	0	2	3	4	25	75
5	BS207	Biophysics	2	0	0	2	2	25	75
6	BS209	Cell & Molecular Biology	2	0	2	3	4	25	75
7	BS211	Plant Biology	1	0	2	2	3	25	75
8	PS201	Technical Seminar	0	0	2	1	2	100	--
TOTAL			14	0	12	20	26	275	525

SEMESTER IV

S. No.	Course Code	Course Title	L	T	P	C	Contact Hours Per Week	Max. Marks	
								C.A	E.S.A
1	PC202	Bioprocess Engineering	2	0	2	3	4	25	75
2	PC204	Green Biotechnology and Pollution Abatement	2	0	0	2	2	25	75
3	PC206	Immunology & Immunotechnology	2	0	2	3	4	25	75
4	PC208	rDNA Technology	2	0	2	3	4	25	75
5	PC210	Structural Biology	2	1	0	3	3	25	75
6	PC212	Bioinformatics & Computational Biology	2	0	2	3	4	25	75
7	AU202	Environmental Science	2 [^]	0	0	0	2	25	75
8	HS202	Engineering Economics	2	0	0	2	2	25	75
9	PS202	Comprehensive viva voce	0	0	2	1	2	100	--
TOTAL			14+2[^]	1	10	20	27	300	600

Note: [^] represents related to Audit Course.

SEMESTER V

S. No.	Course Code	Course Title	L	T	P	C	Contact Hours Per Week	Max. Marks	
								C.A	E.S.A
1	HS301	Entrepreneurship and Startups	1	1	0	2	2	25	75
2	PC301	Metabolic Engineering	2	0	2	3	4	25	75
3	PC303	Analytical Techniques	2	0	2	3	4	25	75
4	PC305	Cheminformatics & Medicinal Chemistry	2	0	2	3	4	25	75
5	PC307	Good Manufacturing and Laboratory Practice	2	1	0	3	3	25	75
6	PEXXX	Professional Elective-I	3	1	2	5	6	25	75
7	OSXXX	Open Subject-I	3	1	2	5	6	25	75
8	AU301	Indian Constitution	2 [^]	0	0	0	2	--	--

9	PS301	Summer Internship-I	0	0	4	2	--	100	--
TOTAL			15+2^	4	14	26	31	275	525

Note: ^ represents related to Audit Course.

SEMESTER VI

S. No.	Course Code	Course Title	L	T	P	C	Contact Hours Per Week	Max. Marks	
								C.A	E.S.A
1	PC302	Bioseparation Engineering	2	0	2	3	4	25	75
2	PC304	Synthetic & Systems Biology	3	0	2	4	5	25	75
3	PC306	Animal & Plant Biotechnology	2	0	4	4	6	25	75
4	PEXXX	Professional Elective-II	3	1	2	5	6	25	75
5	OSXXX	Open Subject-II	3	1	2	5	6	25	75
TOTAL			13	2	12	21	27	125	375

SEMESTER VII

S. No.	Course Code	Course Title	L	T	P	C	Contact Hours Per Week	Max. Marks	
								C.A	E.S.A
1	HS401	Intellectual Property Rights (IPR) & Regulatory	1	1	0	2	2	25	75
2	PC401	Data analysis and simulations	2	0	2	3	4	25	75
3	PEXXX	Professional Elective-III	3	1	2	5	6	25	75
4	PEXXX	Professional Elective-IV	2	1	0	3	3	25	75
5	OSXXX	Open Subject-III	3	1	2	5	6	25	75
6	OSXXX	Open Subject-IV	2	1	0	3	3	25	75
7	PS401	Project-I	0	0	4	2	--	100	--
8	PS403	Summer Internship-II	0	0	6	3	--	100	--
TOTAL			13	5	16	26	28	350	450

SEMESTER VIII

S. No.	Course Code	Name	L	T	P	C	Contact Hours Per Week	Max. marks	
								C.A	E.S.A
1	PS402	Project-II (Biotech Industrial or Biotech In-house Project or Bio-Entrepreneurship/ startups)	0	0	18	9	--	100	200
TOTAL			0	0	18	9	--	100	200

SEMESTER I

SEMESTER I

Course Code	:	BSC101
Course Title	:	Physics- I
Number of Credits	:	5.5 (L: 3, T: 1, P: 3)
Course Category	:	BSC
Course Contents in Physics (Any One)	:	Anyone from the below options i. Introduction to Electromagnetic Theory ii. Introduction to Mechanics iii. Quantum Mechanics for Engineers iv. Oscillation, Waves and Optics

Course Objective(s): To enhance the fundamental knowledge in Physics and its applications relevant to various streams of Engineering and Technology.

Introduction to Electromagnetic Theory
Pre-requisites (if any): Mathematics course with vector calculus

Module 1: Electrostatics in vacuum

Calculation of electric field and electrostatic potential for a charge distribution; Divergence and curl of electrostatic field; Laplace's and Poisson's equations for electrostatic potential and uniqueness of their solution and connection with steady state diffusion and thermal conduction; Practical examples like Faraday's cage and coffee-ring effect; Boundary conditions of electric field and electrostatic potential; method of images; energy of a charge distribution and its expression in terms of electric field.

Module 2: Electrostatics in a linear dielectric medium

Electrostatic field and potential of a dipole. Bound charges due to electric polarization; Electric displacement; boundary conditions on displacement; Solving simple electrostatics problems in presence of dielectrics – Point charge at the centre of a dielectric sphere, charge in front of a dielectric slab, dielectric slab and dielectric sphere in uniform electric field.

Module 3: Magnetostatics

Bio-Savart law, Divergence and curl of static magnetic field; vector potential and calculating it for a given magnetic field using Stokes' theorem; the equation for the vector potential and its solution for given current densities.

Module 4: Magnetostatics in a linear magnetic medium

Magnetization and associated bound currents; auxiliary magnetic field H; Boundary conditions on B and H. Solving for magnetic field due to simple magnets like a bar magnet; magnetic susceptibility and ferromagnetic, paramagnetic and diamagnetic materials; Qualitative discussion of magnetic field in presence of magnetic materials.

Module 5: Faraday’s law

Faraday’s law in terms of EMF produced by changing magnetic flux; equivalence of Faraday’s law and motional EMF; Lenz’s law; Electromagnetic braking and its applications; Differential form of Faraday’s law expressing curl of electric field in terms of time-derivative of magnetic field and calculating electric field due to changing magnetic fields in quasi-static approximation; energy stored in a magnetic field.

Module 6: Displacement current, Magnetic field due to time-dependent electric field and Maxwell’s equations

Continuity equation for current densities; Modifying equation for the curl of magnetic field to satisfy continuity equation; displacement current and magnetic field arising from time dependent electric field; calculating magnetic field due to changing electric fields in quasistatic approximation. Maxwell’s equation in vacuum and non-conducting medium; Energy in an electromagnetic field; Flow of energy and Poynting vector with examples. Qualitative discussion of momentum in electromagnetic fields.

Module 7: Electromagnetic waves

The wave equation; Plane electromagnetic waves in vacuum, their transverse nature and polarization; relation between electric and magnetic fields of an electromagnetic wave; energy carried by electromagnetic waves and examples. Momentum carried by electromagnetic waves and resultant pressure. Reflection and transmission of electromagnetic waves from a non-conducting medium-vacuum interface for normal incidence.

Laboratory - Introduction to Electromagnetic Theory

Choice of experiments from the following:

- Experiments on electromagnetic induction and electromagnetic braking;
- LC circuit and LCR circuit;
- Resonance phenomena in LCR circuits;
- Magnetic field from Helmholtz coil;
- Measurement of Lorentz force in a vacuum tube.

TEXTBOOKS/REFERENCES:

- i. David Griffiths, Introduction to Electrodynamics
- ii. Halliday and Resnick, Physics
- iii. W. Saslow, Electricity, magnetism and light

Introduction to Mechanics
Pre-requisites (if any): High School Education

Module 1

Transformation of scalars and vectors under Rotation transformation; Forces in Nature; Newton’s laws and its completeness in describing particle motion; Form invariance of Newton’s Second Law; Solving Newton’s equations of motion in polar coordinates; Problems including constraints and friction; Extension to cylindrical and spherical coordinates.

Module 2

Potential energy function; $F = -\text{Grad } V$, equipotential surfaces and meaning of gradient; Conservative and non-conservative forces, curl of a force field; Central forces; Conservation of Angular Momentum; Energy equation and energy diagrams; Elliptical, parabolic and hyperbolic orbits; Kepler problem; Application: Satellite manoeuvres;

Module 3

Non-inertial frames of reference; Rotating coordinate system: Five-term acceleration formula. Centripetal and Coriolis accelerations; Applications: Weather systems, Foucault pendulum;

Module 4

Harmonic oscillator; Damped harmonic motion – over-damped, critically damped and lightly-damped oscillators; Forced oscillations and resonance.

Module 5

Definition and motion of a rigid body in the plane; Rotation in the plane; Kinematics in a coordinate system rotating and translating in the plane; Angular momentum about a point of a rigid body in planar motion; Euler's laws of motion, their independence from Newton's laws, and their necessity in describing rigid body motion; Examples.

Module 6

Introduction to three-dimensional rigid body motion — only need to highlight the distinction from two-dimensional motion in terms of (a) Angular velocity vector, and its rate of change and (b) Moment of inertia tensor; Three-dimensional motion of a rigid body wherein all points move in a coplanar manner: e.g. Rod executing conical motion with center of mass fixed — only need to show that this motion looks two-dimensional but is three-dimensional, and two-dimensional formulation fails.

Laboratory - Introduction to Mechanics

1. Suggested list of experiments from the following;
2. Coupled oscillators;
3. Experiments on an air-track;
4. Experiment on moment of inertia measurement,
5. Experiments with gyroscope;
6. Resonance phenomena in mechanical oscillators.

TEXTBOOKS/REFERENCES:

1. Engineering Mechanics, 2nd Ed. — MK Harbola
 2. Introduction to Mechanics — MK Verma
 3. Engineering Mechanics, 2nd Ed. – D.S. Bedi & M.P. Poonia
 4. An Introduction to Mechanics — D Kleppner & R Kolenkow
 5. Principles of Mechanics — JL Synge & BA Griffiths
 6. Mechanics — JP Den Hartog
 7. Engineering Mechanics - Dynamics, 7th ed. - JL Meriam
 8. Mechanical Vibrations — JP Den Hartog
 9. Theory of Vibrations with Applications — WT Thomson
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Quantum Mechanics for Engineers
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Pre-requisites (if any): Mathematics Course on Differential equations & linear algebra
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Module 1: Wave nature of particles and the Schrodinger equation

Introduction to Quantum mechanics, Wave nature of Particles, Time-dependent and time independent Schrodinger equation for wave function, born interpretation, probability current, Expectations values, Free-particle wave function and wave-packets, Uncertainty principle.

Module 2: Mathematical Preliminaries for quantum mechanics

Complex numbers, Linear vector spaces, inner product, operators, eigenvalue problems, Hermitian operators, Hermite polynomials, Legendre's equation, spherical harmonics.

Module 3: Applying the Schrodinger equation

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. Numerical solution of stationary-state Schrodinger equation for one dimensional problems for different potentials Scattering from a potential barrier and tunneling; related examples like alpha-decay, field ionization and scanning tunneling microscope Three-dimensional problems: particle in three dimensional box and related examples, Angular momentum operator, Rigid Rotor, Hydrogen atom ground-state, orbitals, interaction with magnetic field, spin, Numerical solution stationary-state radial Schrodinger equation for spherically symmetric potentials.

Module 4: Introduction to molecular bonding

Particle in double delta-function potential, Molecules (hydrogen molecule, valence bond and molecular orbitals picture), singlet/triplet states, chemical bonding, hybridization.

Module 5: Introduction to solids

Free electron theory of metals, Fermi level, density of states, Application to white dwarfs and neutron stars, Bloch's theorem for particles in a periodic potential, Kronig-Penney model and origin of energy bands Numerical solution for energy in one-dimensional periodic lattice by mixing plane waves.

Laboratory - Quantum Mechanics for Engineers

Suggested list of experiments: Frank-Hertz experiment; photoelectric effect experiment; recording hydrogen atom spectrum.

TEXTBOOKS/REFERENCES:

1. Eisberg and Resnick, Introduction to Quantum Physics
2. D. J. Griffiths, Quantum Mechanics
3. Richard Robinett, Quantum Mechanics
4. Daniel McQuarrie, Quantum Chemistry

Oscillations, waves and optics

Pre-requisites (if any): Mathematics Course on Differential equations

Module 1: Simple harmonic motion, damped and forced simple harmonic oscillator

Mechanical and electrical simple harmonic oscillators, complex number notation and phasor representation of simple harmonic motion, damped harmonic oscillator – heavy, critical and light damping, energy decay in a damped harmonic oscillator, quality factor, forced mechanical and electrical oscillators, electrical and mechanical impedance, steady state motion of forced damped harmonic oscillator, power absorbed by oscillator.

Module 2: Non-dispersive transverse and longitudinal waves in one dimension and introduction to dispersion

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 and speed of sound, standing sound waves. Waves with dispersion, water waves, superposition of waves and Fourier method, wave groups and group velocity.

Module 3: The propagation of light and geometric optics

Fermat's principle of stationary time and its applications e.g. in explaining mirage effect, laws of reflection and refraction, 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, transfer formula and the matrix method.

Module 4: Wave optics (6 lectures)

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.

Fraunhofer 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

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, CO₂), solid-state lasers (ruby, Neodymium), dye lasers; Properties of laser beams: monochromaticity, coherence, directionality and brightness, laser speckles, applications of lasers in science, engineering and medicine.

Laboratory - Oscillations, waves and optics

Suggested list of experiments from the following:

- Diffraction and interference experiments (from ordinary light or laser pointers); measurement of speed of light on a table top using modulation; minimum deviation from a prism.

TEXTBOOKS/REFERENCES:

1. Ian G. Main, Oscillations and waves in physics
2. H.J. Pain, The physics of vibrations and waves
3. E. Hecht, Optics
4. A. Ghatak, Optics

5. O. Svelto, Principles of Lasers

Course Code	:	BSC103
Course Title	:	Mathematics- I
Number of Credits	:	4 (L: 3, T: 1, P: 0)
Course Category	:	BSC

Course Objective(s): The goal of this course is to achieve conceptual understanding and to retain the best traditions of traditional calculus. The syllabus is designed to provide the basic tools of calculus mainly for the purpose of modelling the engineering problems mathematically and obtaining solutions. This is a foundation course which mainly deals with topics such as single variable and multivariable calculus and plays an important role in the understanding of science, engineering, economics and computer science, among other disciplines.

Course Contents:

Module 1: Calculus

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's theorems with remainders; indeterminate forms and L'Hospital's rule; Maxima and minima.

Module 2: Sequences and Series

Convergence of sequences 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)

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: 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, and Orthogonal transformation.

Textbooks/References:

1. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
2. Reena Garg, Engineering Mathematics – I, Khanna Book Publishing Co., 2018.
3. Reena Garg & Chandrika Prasad, Advanced Engineering Mathematics, Khanna Book Publishing Co., 2018.

4. Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
5. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
6. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
7. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
8. N.P. Bali and Manish Goyal, A textbook of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
9. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.

Course Outcomes: The objective of this course is to familiarize the prospective engineers with techniques in calculus, multivariate analysis and linear algebra. It aims to equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards tackling more advanced level of mathematics and applications that they would find useful in their disciplines.

The students will learn:

- To apply differential and integral calculus to notions of curvature and to improper integrals. Apart from some other applications they will have a basic understanding of Beta and Gamma functions.
- The fallouts of Rolle’s Theorem that is fundamental to the application of analysis to Engineering problems.
- The tool of power series and Fourier series for learning advanced Engineering Mathematics.
- To deal with functions of several variables that are essential in most branches of engineering.
- The essential tool of matrices and linear algebra in a comprehensive manner.

Course Code	:	ESC101
Course Title	:	Basic Electrical Engineering
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	ESC

Course Objective(s): The objective of this Course is to provide the students with an introductory and broad treatment of the field of Electrical Engineering.

Course Contents:

Module 1: D. C. Circuits covering, Ohm's Law and Kirchhoff's Laws; Analysis of series, parallel and series-parallel circuits excited by independent voltage sources; Power and energy; Electromagnetism covering, Faraday's Laws, Lenz's Law, Fleming's Rules, Statically and dynamically induced EMF; Concepts of self-inductance, mutual inductance and coefficient of coupling; Energy stored in magnetic fields;

Module 2: Single Phase A.C. Circuits covering, Generation of sinusoidal voltage-definition of average value, root mean square value, form factor and peak factor of sinusoidal voltage and current and phasor representation of alternating quantities; Analysis with phasor diagrams of R, L, C, RL, RC and RLC circuits; Real power, reactive power, apparent power and power factor, series, parallel and series- parallel circuits; Three Phase A.C. Circuits covering, Necessity and Advantages of three phase systems, Generation of three phase power, definition of Phase sequence, balanced supply and balanced load; Relationship between line and phase values of balanced star and delta connections; Power in balanced three phase circuits, measurement of power by two wattmeter method;

Module 3: Transformers covering, Principle of operation and construction of single phase transformers (core and shell types). EMF equation, losses, efficiency and voltage regulation; Synchronous Generators covering, Principle of operation; Types and constructional features; EMF equation;

Module 4: DC Machines covering, working principle of DC machine as a generator and a motor; Types and constructional features; EMF equation of generator, relation between EMF induced and terminal voltage enumerating the brush drop and drop due to armature reaction; DC motor working principle; Back EMF and its significance, torque equation; Types of D.C. motors, characteristics and applications; Necessity of a starter for DC motor;

Module 5: Three Phase Induction Motors covering; Concept of rotating magnetic field; Principle of operation, types and constructional features; Slip and its significance; Applications of squirrel cage and slip ring motors; Necessity of a starter, star-delta starter.

Module 6: Sources of Electrical Power covering, Introduction to Wind, Solar, Fuel cell, Tidal, Geo-thermal, Hydroelectric, Thermal-steam, diesel, gas, nuclear power plants; Concept of cogeneration, and distributed generation;

Text/Reference Books:

1. Nagrath I.J. and D. P. Kothari (2001), Basic Electrical Engineering, Tata McGraw Hill.
2. Hayt and Kimberly, Engineering Circuit Analysis, Tata McGraw Hill.
3. Kulshreshtha D.C. (2009), Basic Electrical Engineering, Tata McGraw Hill.
4. Rajendra Prasad (2009), Fundamentals of Electrical Engineering, Prentice Hall, India
5. Sahdev Ritu (2018), Basic Electrical Engineering, Khanna Book Publishing Co.

Course Outcomes:

1. Students will learn strong basics of Electrical Engineering and practical implementation of Electrical fundamentals.
2. Students will learn different applications of commonly used electrical machinery.

Course Code	:	ESC103
Course Title	:	Engineering Graphics & Design
Number of Credits	:	3 (L: 1, T: 0, P: 4)
Course Category	:	ESC

Course Objective(s): The objective of this Course is to provide the basic knowledge about Engineering Drawing. Detailed concepts are given in projections, technical drawing, dimensioning and specifications, so useful for a student in preparing for an engineering career.

Course Contents:

Traditional Engineering Graphics: Principles of Engineering Graphics; Orthographic Projection; Descriptive Geometry; Drawing Principles; Isometric Projection; Surface Development; Perspective; Reading a Drawing; Sectional Views; Dimensioning & Tolerances; True Length, Angle; intersection, Shortest Distance.

Computer Graphics: Engineering Graphics Software; -Spatial Transformations; Orthographic Projections; Model Viewing; Coordinate Systems; Multi-view Projection; Exploded Assembly; Model Viewing; Animation; Spatial Manipulation; Surface Modelling; Solid Modelling; Introduction to Building Information Modelling (BIM).

(Except the basic essential concepts, most of the teaching part can happen concurrently in the laboratory)

Module 1: Introduction to Engineering Drawing

Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering, Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloid, Hypocycloid and Involute; Scales – Plain, Diagonal and Vernier Scales;

Module 2: Orthographic Projections

Principles of Orthographic Projections-Conventions - Projections of Points and lines inclined to both planes; Projections of planes inclined Planes - Auxiliary Planes;

Module 3: Projections of Regular Solids

Covering those inclined to both the Planes- Auxiliary Views; Draw simple annotation, dimensioning and scale. Floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc.

Module 4: Sections and Sectional Views of Right Angular Solids

Prism, Cylinder, Pyramid, Cone – Auxiliary Views; Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids, objects from industry and dwellings (foundation to slab only).

Module 5: Isometric Projections

Principles of Isometric projection – Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa, Conventions;

Module 6: Overview of Computer Graphics

Listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software [such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects; Isometric Views of lines, Planes, Simple and compound Solids];

Module 7: Customization & CAD Drawing

Consisting of set up of the drawing page and the printer, including scale settings, setting up of units and drawing limits; ISO and ANSI standards for coordinate dimensioning and tolerancing; Orthographic constraints, Snap to objects manually and automatically; Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles;

Module 8: Annotations, layering & other functions

Covering applying dimensions to objects, applying annotations to drawings; Setting up and use of Layers, layers to create drawings, Create, edit and use customized layers; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command; orthographic projection techniques; Drawing sectional views of composite right regular geometric solids and project the true shape of the sectioned surface; Drawing annotation, Computer-aided design (CAD) software modeling of parts and assemblies. Parametric and non-parametric solid, surface, and wireframe models. Part editing and two-dimensional documentation of models. Planar projection theory, including sketching of perspective, isometric, multiview, auxiliary, and section views. Spatial visualization exercises. Dimensioning guidelines, tolerancing techniques; dimensioning and scale multi views of dwelling;

Module 9: Demonstration of a simple team design project that illustrates Geometry and topology of engineered components: creation of engineering models and their presentation in standard 2D blueprint form and as 3D wire-frame and shaded solids; meshed topologies for engineering analysis and tool-path generation for component manufacture; geometric dimensioning and tolerance; Use of solid-modeling software for creating associative models at the component and assembly levels; floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc. Applying colour coding according to building drawing practice; Drawing sectional elevation showing foundation to ceiling; Introduction to Building Information Modelling (BIM).

Text/Reference Books:

1. Jain Pradeep, Gautam A.P. & Maheshwari Ankita (2018), Engineering Graphics & Design, Khanna Publishing House.
2. Bhatt N.D., Panchal V.M. & Ingle P.R., (2014), Engineering Drawing, Charotar Publishing House.

3. Shah, M.B. & Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson Education.
4. Agrawal B. & Agrawal C. M. (2012), Engineering Graphics, TMH Publication
5. Narayana, K.L. & P Kannaiah (2008), Text book on Engineering Drawing, Scitech Publishers.
6. (Corresponding set of) CAD Software Theory and User Manuals.

Course Outcomes: All phases of manufacturing or construction require the conversion of new ideas and design concepts into the basic line language of graphics. Therefore, there are many areas (civil, mechanical, electrical, architectural and industrial) in which the skills of the CAD technicians play major roles in the design and development of new products or construction. Students prepare for actual work situations through practical training in a new state-of-the-art computer designed CAD laboratory using engineering software. This course is designed to address:

- to prepare you to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- to prepare you to communicate effectively
- to prepare you to use the techniques, skills, and modern engineering tools necessary for engineering practice

The student will learn:

- Introduction to engineering design and its place in society.
- Exposure to the visual aspects of engineering design.
- Exposure to engineering graphics standards.
- Exposure to solid modelling.
- Exposure to computer-aided geometric design.
- Exposure to creating working drawings.
- Exposure to engineering communication.

SEMESTER II

SEMESTER II

Course Code	:	BSC102
Course Title	:	Chemistry- I
Number of Credits	:	5.5 (L: 3, T: 1, P: 3)
Course Category	:	BSC

Course Objective(s): The objective of the Chemistry I is to acquaint the students with the basic phenomenon/concepts of chemistry, the student faces during the course of their study in the industry and Engineering field. The student with the knowledge of the basic chemistry, will understand and explain scientifically the various chemistry related problems in the industry/engineering field. The student will be able to understand the new developments and breakthroughs efficiently in engineering and technology. The introduction of the latest (R&D oriented) topics will make the engineering student upgraded with new technologies.

Course Contents:

(i) Atomic and Molecular Structure

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 multicenter orbitals. Equations for atomic and molecular orbitals. Energy level diagrams of diatomic. 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.

(ii) Spectroscopic techniques and applications

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.

(iii) Intermolecular forces and potential energy surfaces

Ionic, dipolar and van Der Waals interactions. Equations of state of real gases and critical phenomena. Potential energy surfaces of H₃, H₂F and HCN and trajectories on these surfaces.

(iv) Use of free energy in chemical equilibria (6 lectures)

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.

(v) Periodic properties

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 and soft acids and bases, molecular geometries.

(vi) Stereochemistry

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 transition metal compounds.

(vii) Organic reactions and synthesis of a drug molecule

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

Laboratory: 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 viscometers to demonstrate of the isoelectric point as the pH of minimum viscosity for gelatin sols and/or coagulation of the white part of the egg.

Text/Reference books:

1. University chemistry, by B. H. Mahan
2. Engineering Chemistry, by Satyaprakash & Manisha Agarwal
3. Chemistry: Principles and Applications, by M. J. Sienko and R. A. Plane
4. Fundamentals of Molecular Spectroscopy, by C. N. Banwell
5. Engineering Chemistry (NPTEL Web-book), by B. L. Tembe, Kamaluddin and M. S. Krishnan
6. Physical Chemistry, by P. W. Atkins
7. Organic Chemistry: Structure and Function by K. P. C. Vollhardt and N. E. Schore, 5th Edition <http://bcs.whfreeman.com/vollhardtschore5e/default.asp>

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 the 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.

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 analyze a salt sample.

Course Code	:	BSC104
Course Title	:	Mathematics- II
Number of Credits	:	4 (L: 3, T: 1, P: 0)
Course Category	:	BSC

Course Contents:

Module 1: Multivariable Calculus (Integration)

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

Module 2: First order ordinary differential equations

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 3: Ordinary differential equations of higher orders

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 4: Complex Variable – Differentiation

Differentiation, Cauchy-Riemann equations, analytic functions, harmonic functions, finding harmonic conjugate; elementary analytic functions (exponential, trigonometric, logarithm) and their properties; Conformal mappings, Mobius transformations and their properties.

Module 5: Complex Variable – Integration

Contour integrals, Cauchy-Goursat theorem (without proof), Cauchy Integral formula (without proof), Liouville's theorem and Maximum-Modulus theorem (without proof); Taylor's series, zeros of analytic functions, singularities, Laurent's series; Residues, Cauchy Residue theorem (without proof), Evaluation of definite integral involving sine and cosine, Evaluation of certain improper integrals using the Bromwich contour.

Text Books/References:

1. Chandrika Prasad & Reena Garg, Advanced Engineering Mathematics, Khanna Publishing House, 2018.
2. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
3. Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
4. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9th Edn., Wiley India, 2009.
5. S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.
6. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
7. E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
8. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th Ed., McGraw Hill, 2004.
9. N.P. Bali and Manish Goyal, A textbook of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
10. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.

Course Outcomes: The objective of this course is to familiarize the prospective engineers with techniques in multivariate integration, ordinary and partial differential equations and complex variables. It aims to equip the students to deal with advanced level of mathematics and applications that would be essential for their disciplines.

The students will learn:

- The mathematical tools needed in evaluating multiple integrals and their usage.
- The effective mathematical tools for the solutions of differential equations that model physical processes.
- The tools of differentiation and integration of functions of a complex variable that are used in various techniques dealing engineering problems.

Course Code	:	ESC102
Course Title	:	Programming for Problem Solving
Number of Credits	:	5 (L: 3, T: 0, P: 4)
Course Category	:	ESC

Course Contents:

Unit 1: Introduction to Programming; Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, compilers etc.)

Idea of Algorithm: steps to solve logical and numerical problems. Representation of Algorithm: Flowchart/Pseudocode with examples.

From algorithms to programs; source code, variables (with data types) variables and memory locations, Syntax and Logical Errors in compilation, object and executable code.

Unit 2: Arithmetic expressions and precedence

Unit 3: Conditional Branching and Loops. Writing and evaluation of conditionals and consequent branching. Iteration and loops.

Unit 4: Arrays, Arrays (1-D, 2-D), Character arrays and Strings

Unit 5: Basic Algorithms, Searching, Basic Sorting Algorithms (Bubble, Insertion and Selection), Finding roots of equations, notion of order of complexity through example programs (no formal definition required)

Unit 6: Function, Functions (including using built in libraries), Parameter passing in functions, call by value, Passing arrays to functions: idea of call by reference

Unit 7: Recursion, Recursion as a different way of solving problems. Example programs, such as Finding Factorial, Fibonacci series, Ackerman function etc. Quick sort or Merge sort.

Unit 8: Structures, Defining structures and Array of Structures

Unit 9: Pointers, Idea of pointers, Defining pointers, Use of Pointers in self-referential structures, notion of linked list (no implementation)

Unit 10: File handling (only if time is available, otherwise should be done as part of the lab).

Practicals:

1. Familiarization with programming environment
2. Simple computational problems using arithmetic expressions
3. Problems involving if-then-else structures
4. Iterative problems e.g., sum of series
5. 1D Array manipulation
6. Matrix problems, String operations
7. Simple functions
8. Programming for solving Numerical methods problems
9. Recursive functions
10. Pointers and structures
11. File operations

Text/Reference books:

1. R.S. Salaria, Problem Solving & Programming in C, Khanna Book Publishing Co.
2. Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill.

3. E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill.
4. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hall of India.
5. R.S. Salaria, Computer Concepts and Programming in C, Khanna Publishing House.

Course Outcomes: The student will learn following through lectures:

- To formulate simple algorithms for arithmetic and logical problems.
- To translate the algorithms to programs (in the C language).
- To test and execute the programs and correct syntax and logical errors.
- To implement conditional branching, iteration and recursion.
- To decompose a problem into functions and synthesize a complete program using divide and conquer approach.
- To use arrays, pointers and structures to formulate algorithms and programs.
- To apply programming to solve matrix addition and multiplication problems and searching and sorting problems.
- To apply programming to solve simple numerical method problems, namely root finding of function, differentiation of function and simple integration.

The student will learn following through Practicals:

- To formulate the algorithms for simple problems.
- To translate given algorithms to a working and correct program.
- To be able to correct syntax errors as reported by the compilers.
- To be able to identify and correct logical errors encountered at run time.
- To be able to write iterative as well as recursive programs.
- To be able to represent data in arrays, strings and structures and manipulate them through a program.
- To be able to declare pointers of different types and use them in defining self-referential structures.
- To be able to create, read and write to and from simple text files.

Course Code	:	HS102
Course Title	:	English
Number of Credits	:	3 (L: 2, T: 0, P: 2)
Course Category	:	HS

Course Contents:

1. Vocabulary Building
 - 1.1. The concept of Word Formation
 - 1.2. Root words from foreign languages and their use in English
 - 1.3. Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives.
 - 1.4. Synonyms, antonyms, and standard abbreviations.
2. Basic Writing Skills
 - 2.1. Sentence Structures
 - 2.2. Use of phrases and clauses in sentences
 - 2.3. Importance of proper punctuation
 - 2.4. Creating coherence

- 2.5. Organizing principles of paragraphs in documents
 - 2.6. Techniques for writing precisely
 - 3. Identifying Common Errors in Writing
 - 3.1. Subject-verb agreement
 - 3.2. Noun-pronoun agreement
 - 3.3. Misplaced modifiers
 - 3.4. Articles
 - 3.5. Prepositions
 - 3.6. Redundancies
 - 3.7. Clichés
 - 4. Nature and Style of sensible Writing
 - 4.1. Describing
 - 4.2. Defining
 - 4.3. Classifying
 - 4.4. Providing examples or evidence
 - 4.5. Writing introduction and conclusion
 - 5. Writing Practices
 - 5.1. Comprehension
 - 5.2. Précis Writing
 - 5.3. Essay Writing
 - 6. Oral Communication
- (This unit involves interactive practice sessions in Language Lab)
- Listening Comprehension
 - Pronunciation, Intonation, Stress and Rhythm
 - Common Everyday Situations: Conversations and Dialogues
 - Communication at Workplace
 - Interviews
 - Formal Presentations

Suggested Readings:

1. Practical English Usage. Michael Swan. OUP. 1995.
2. Remedial English Grammar. F.T. Wood. Macmillan.2007
3. On Writing Well. William Zinsser. Harper Resource Book. 2001
4. Study Writing. Liz Hamp-Lyons and Ben Heasley. Cambridge University Press. 2006.
5. Communication Skills. Sanjay Kumar and PushpLata. Oxford University Press. 2011.
6. Effective Communication Skills. Kulbhushan Kumar. Khanna Publishing House. 2018.
7. Exercises in Spoken English. Parts. I-III. CIEFL, Hyderabad. Oxford University Press.

Course Outcomes: The student will acquire basic proficiency in English including reading and listening comprehension, writing and speaking skills.

Course Code	:	ESC104
Course Title	:	Workshop/Manufacturing Practices
Number of Credits	:	3 (L: 1, T: 0, P: 4)
Course Category	:	ESC

Course Contents:

1. Manufacturing Methods- casting, forming, machining, joining, advanced manufacturing methods.
2. CNC machining, Additive manufacturing.
3. Fitting operations & power tools.
4. Electrical & Electronics.
5. Carpentry.
6. Plastic moulding, glass cutting.
7. Metal casting.
8. Welding (arc welding & gas welding), brazing.

Practicals:

1. Machine shop (10 hours)
2. Fitting shop (8 hours)
3. Carpentry (6 hours)
4. Electrical & Electronics (8 hours)
5. Welding shop (8 hours: Arc welding 4 hrs + Gas welding 4 hrs)
6. Casting (8 hours)
7. Smithy (6 hours)
8. Plastic moulding & Glass Cutting (6 hours)

Examinations could involve the actual fabrication of simple components, utilizing one or more of the techniques covered above.

Text Books/References:

1. Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., “Elements of Workshop Technology”, Vol. I 2008 and Vol. II 2010, Media promoters and publishers private limited, Mumbai.
2. Kalpakjian S. And Steven S. Schmid, “Manufacturing Engineering and Technology”, 4th edition, Pearson Education India Edition, 2002.
3. Gowri P. Hariharan and A. Suresh Babu,” Manufacturing Technology – I” Pearson Education, 2008.
4. Roy A. Lindberg, “Processes and Materials of Manufacture”, 4th edition, Prentice Hall India, 1998.
5. Rao P.N., “Manufacturing Technology”, Vol. I and Vol. II, Tata McGraw Hill House, 2017.

Course Outcomes: Upon completion of this course, the students will gain knowledge of the different manufacturing processes which are commonly employed in the industry, to fabricate components using different materials.

Laboratory Outcomes:

- Upon completion of this laboratory course, students will be able to fabricate components with their own hands.
- They will also get practical knowledge of the dimensional accuracies and dimensional tolerances possible with different manufacturing processes.
- By assembling different components, they will be able to produce small devices of their interest.

Course Code	:	AU102
Course Title	:	Sports and Yoga
Number of Credits	:	0 (L: 2 [^] , T: 0, P: 0)
Course Category	:	AU

Course Objective(s):

- To make the students understand the importance of sound health and fitness principles as they relate to better health.
- To expose the students to a variety of physical and yogic activities aimed at stimulating their continued inquiry about Yoga, physical education, health and fitness.
- To create a safe, progressive, methodical and efficient activity based plan to enhance improvement and minimize risk of injury.
- To develop among students an appreciation of physical activity as a lifetime pursuit and a means to better health.

Course Contents:

- **Introduction to Physical Education**
 - Meaning & definition of Physical Education
 - Aims & Objectives of Physical Education
 - Changing trends in Physical Education
- **Olympic Movement**
 - Ancient & Modern Olympics (Summer & Winter)
 - Olympic Symbols, Ideals, Objectives & Values
 - Awards and Honours in the field of Sports in India (Dronacharya Award, Arjuna Award, Dhayanchand Award, Rajiv Gandhi Khel Ratna Award etc.)
- **Physical Fitness, Wellness & Lifestyle**
 - Meaning & Importance of Physical Fitness & Wellness
 - Components of Physical fitness
 - Components of Health related fitness
 - Components of wellness
 - Preventing Health Threats through Lifestyle Change
 - Concept of Positive Lifestyle
- **Fundamentals of Anatomy & Physiology in Physical Education, Sports and Yoga**
 - Define Anatomy, Physiology & Its Importance
 - Effect of exercise on the functioning of Various Body Systems. (Circulatory System, Respiratory System, Neuro-Muscular System etc.)
- **Kinesiology, Biomechanics & Sports**
 - Meaning & Importance of Kinesiology & Biomechanics in Physical Edu. & Sports
 - Newton's Law of Motion & its application in sports.
 - Friction and its effects in Sports.

- **Postures**
 - Meaning and Concept of Postures.
 - Causes of Bad Posture.
 - Advantages & disadvantages of weight training.
 - Concept & advantages of Correct Posture.
 - Common Postural Deformities – Knock Knee; Flat Foot; Round Shoulders; Lordosis, Kyphosis, Bow Legs and Scoliosis.
 - Corrective Measures for Postural Deformities
- **Yoga**
 - Meaning & Importance of Yoga
 - Elements of Yoga
 - Introduction - Asanas, Pranayama, Meditation & Yogic Kriyas
 - Yoga for concentration & related Asanas (Sukhasana; Tadasana; Padmasana & Shashankasana)
 - Relaxation Techniques for improving concentration - Yog-nidra
- **Yoga & Lifestyle**
 - Asanas as preventive measures.
 - Hypertension: Tadasana, Vajrasana, Pavan Muktasana, Ardha Chakrasana, Bhujangasana, Sharasana.
 - Obesity: Procedure, Benefits & contraindications for Vajrasana, Hastasana, Trikonasana, Ardh Matsyendrasana.
 - Back Pain: Tadasana, Ardh Matsyendrasana, Vakrasana, Shalabhasana, Bhujangasana.
 - Diabetes: Procedure, Benefits & contraindications for Bhujangasana, Paschimottasana, Pavan Muktasana, Ardh Matsyendrasana.
 - Asthema: Procedure, Benefits & contraindications for Sukhasana, Chakrasana, Gomukhasana, Parvatasana, Bhujangasana, Paschimottasana, Matsyasana.
- **Training and Planning in Sports**
 - Meaning of Training
 - Warming up and limbering down
 - Skill, Technique & Style
 - Meaning and Objectives of Planning.
 - Tournament – Knock-Out, League/Round Robin & Combination.
- **Psychology & Sports**
 - Definition & Importance of Psychology in Physical Edu. & Sports
 - Define & Differentiate Between Growth & Development
 - Adolescent Problems & Their Management
 - Emotion: Concept, Type & Controlling of emotions
 - Meaning, Concept & Types of Aggressions in Sports.
 - Psychological benefits of exercise.
 - Anxiety & Fear and its effects on Sports Performance.
 - Motivation, its type & techniques.
 - Understanding Stress & Coping Strategies.

- **Doping**
 - Meaning and Concept of Doping
 - Prohibited Substances & Methods
 - Side Effects of Prohibited Substances
- **Sports Medicine**
 - First Aid – Definition, Aims & Objectives.
 - Sports injuries: Classification, Causes & Prevention.
 - Management of Injuries: Soft Tissue Injuries and Bone & Joint Injuries
- **Sports / Games**

Following subtopics related to any one Game/Sport of choice of student out of: Athletics, Badminton, Basketball, Chess, Cricket, Kabaddi, Lawn Tennis, Swimming, Table Tennis, Volleyball, Yoga etc.

 - History of the Game/Sport.
 - Latest General Rules of the Game/Sport.
 - Specifications of Play Fields and Related Sports Equipment.
 - Important Tournaments and Venues.
 - Sports Personalities.
 - Proper Sports Gear and its Importance.

Text Books/References:

1. Modern Trends and Physical Education by Prof. Ajmer Singh.
2. Light On Yoga by B.K.S. Iyengar.
3. Health and Physical Education – NCERT (11th and 12th Classes)

Course Outcomes: On successful completion of the course the students will be able to:

1. Practice Physical activities and Hatha Yoga focusing on yoga for strength, flexibility, and relaxation.
2. Learn techniques for increasing concentration and decreasing anxiety which leads to stronger academic performance.
3. Learn breathing exercises and healthy fitness activities
4. Understand basic skills associated with yoga and physical activities including strength and flexibility, balance and coordination.
5. Perform yoga movements in various combination and forms.
6. Assess current personal fitness levels.
7. Identify opportunities for participation in yoga and sports activities.
8. Develop understanding of health-related fitness components: cardiorespiratory endurance, flexibility and body composition etc.
9. Improve personal fitness through participation in sports and yogic activities.
10. Develop understanding of psychological problems associated with the age and lifestyle.
11. Demonstrate an understanding of sound nutritional practices as related to health and physical performance.
12. Assess yoga activities in terms of fitness value.
13. Identify and apply injury prevention principles related to yoga and physical fitness activities.

14. Understand and correctly apply biomechanical and physiological principles related to exercise and training.

SEMESTER III

Semester III

Course Code	:	HS201
Course Title	:	Effective Technical Communication
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Course Category	:	HS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The students will acquire knowledge on various types of listening techniques, barriers and benefits of listening recognize the speech sounds and learn the intonation patterns, learn various vocabulary patterns, develop the ability to structure and punctuate the sentences, learn different reading techniques learn different writing skills.

Course Contents:

Module 1: Information Design and Development- Different kinds of technical documents, Information development life cycle, Organization structures, factors affecting information and document design, Strategies for organization, Information design and writing for print and online media.

Module 2: Technical Writing, Grammar and Editing- Technical writing process, forms of discourse, writing drafts and revising, Collaborative writing, creating indexes, technical writing style and language. Basics of grammar, study of advanced grammar, editing strategies to achieve appropriate technical style. Introduction to advanced technical communication, Usability, Human factors, Managing technical communication projects, time estimation, Single sourcing, Localization.

Module 3: Self Development and Assessment- Self assessment, Awareness, Perception and Attitudes, Values and belief, Personal goal setting, career planning, Self-esteem. Managing Time; Personal memory, Rapid reading, taking notes; Complex problem solving; Creativity.

Module 4: Communication and Technical Writing- Public speaking, Group discussion, Oral; presentation, Interviews, Graphic presentation, Presentation aids, Personality Development. Writing reports, project proposals, brochures, newsletters, technical articles, manuals, official notes, business letters, memos, progress reports, minutes of meetings, event report.

Module 5: Ethics- Business ethics, Etiquettes in social and office settings, Email etiquettes, Telephone Etiquettes, Engineering ethics, managing time, Role and responsibility of engineer, Work culture in jobs, Personal memory, Rapid reading, taking notes, Complex problem solving, Creativity.

Text Books/References:

1. Effective Communication Skills. Kulbushan Kumar. Khanna Publishing House. 2018.

2. David F. Beer and David McMurrey, Guide to writing as an Engineer, John Willey. New York, 2004.
3. Diane Hacker, Pocket Style Manual, Bedford Publication, New York, 2003. (ISBN 0312406843).
4. Shiv Khera, You Can Win, Macmillan Books, New York, 2003.
5. Raman Sharma, Technical Communications, Oxford Publication, London, 2004.
6. Dale Jungk, Applied Writing for Technicians, McGraw Hill, New York, 2004. (ISBN: 07828357-4)
7. Sharma, R. and Mohan, K. Business Correspondence and Report Writing, TMH. 2002.
8. Xebec, Presentation Book, TMH New Delhi, 2000.

Course Code	:	BS201
Course Title	:	Biochemistry
Number of Credits	:	3 (L: 2, T: 0, P: 2)
Course Category	:	BS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): It is intended to impart basic undergraduate-level knowledge in the area of general Biochemistry. Students would be able to understand the biochemical basis of cellular functions and organism physiology. They would also be able to assimilate recent research findings, advancement and development in the relevant subject.

Course Contents: Introduction to biological buffers and its importance in biochemistry, pH, water, basics of amino acids, pK and pI values of amino acids, pK values of the ionizable groups of proteins, peptide bond, peptide, protein structures, protein stability and folding, native structure of protein, protein methodology, enzymes and kinetics, nucleotide, biochemistry of nucleic acids, lipids and membrane, carbohydrates, introduction to metabolism, Glucose metabolism, citric acid cycle, electron transport chain, amino acid and lipid metabolism, haemoglobins, regulation and integration of metabolic pathways and the biochemical basis of human diseases (e.g. diabetes), Biochemical techniques.

Practical Exercise:

1. Estimate quality and quantity of the carbohydrates
2. Analyse quality and quantity of the lipids
3. Analyse quality and quantity of the DNA, RNA
4. Estimate quality and quantity of the proteins
5. Estimate lysozyme enzymatic activity
6. Estimate quantity of sugar from given sample

Text Books/References:

1. Principles of Biochemistry by David L. Nelson and Michael M. Cox
2. Biochemistry by Geoffrey Zubey

3. Biochemistry. 5th edition. Berg JM, Tymoczko JL, Stryer L. New York: W H Freeman; 2002.
4. Essentials of Glycobiology [Internet]. 3rd edition. Varki A, Cummings RD, Esko JD, et al., editors. Cold Spring Harbor (NY): Cold Spring Harbor Laboratory Press; 2015-2017.
5. Basic Neurochemistry: Molecular, Cellular and Medical Aspects. 6th edition. Siegel GJ, Agranoff BW, Albers RW, et al, editors. Philadelphia: Lippincott-Raven; 1999.

Course Outcomes: After completion of the course, students would get a good grasp of the biochemical basis of cellular functions and organism physiology.

Course Code	:	BS203
Course Title	:	Microbiology
Number of Credits	:	3 (L: 2, T: 0, P: 2)
Course Category	:	BS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The course provides the students with a conceptual and experimental background in the broad discipline of microbiology. The students will be introduced to the major groups of microorganisms and their diversity in structure and functions and microbial interactions. Emphasis has been laid on bacterial growth, nutrition, control, metabolism, and genetics. The course also introduces the students to the scope and relevance of microbes in the field of medicine, agriculture, and industry.

Course Contents: Introduction to Microbiology (History and Scope- Role of Microbes in agriculture, public health, medicine and industry).

Organization of Prokaryotic and Eukaryotic Cell Structure and Function.

Diversity of the Microbial World- (Microbial Evolution, Taxonomy, Microbial Diversity).

The Viruses.

Microbial Nutrition and Growth (Types of growth media, growth phases, culture methods).

Microbial Metabolism (Aerobic & anaerobic respiration, fermentation, Entner Duodruffs pathway, photosynthesis, nitrogen fixation).

Microbial Molecular Biology and Genetics (Genome and gene structure, Replication, Expression, Regulation of gene expression (operon system), transformation conjugation and transduction)).

Microbial Ecology (Microbes from Marine, Freshwater and Terrestrial Environments)

Microbial Interactions (Symbiotic, non-symbiotic)).

Pathogenic Microbes.

Control of microbial growth – (Effect of heat, Sterilization, disinfectants, therapeutic agents, antimicrobial resistance).

Applications in Food and Industrial Microbiology.

Practicals:

1. Microbial Good Lab Practices and Biosafety

2. Media preparation, sterilization and disinfection
3. Microscopic examination of different groups of microorganisms
4. Total count and viable count determination
5. Microbial simple and differential staining methods
6. Isolation of pure culture and its preservation
7. Microbial Growth Curve Determination
8. Effect of physical and chemical environment on growth
9. Biochemical tests for microbial identification
10. Antibiotic Sensitivity of Microorganisms

Text Books/References:

1. Prescott's Microbiology by Willey, Sherwood and Woolverton.
2. Brock Biology of Microorganisms by Madigan, Martinko, Stahl and Clark.
3. General Microbiology by Stanier, Ingraham, Wheelis and Painter.
4. Microbiology, M. Pelczar, E. Chan, N. Kreig, 5th ed, MGH.

Course Outcomes: At the end of the course, students will be aware of the conspicuous presence of microbes in the environment and their influence in our daily lives as part of the food, soil, air environment, and disease development. The students will be excited to know the immense diversity in the microbial world, their varied inter or intra-community interactions and contribution to the biotech industry. Many students would be inspired to go for the advanced microbial course and pursue basic or applied microbial research.

Course Code	:	BS205
Course Title	:	Genetics
Number of Credits	:	3 (L: 2, T: 0, P: 2)
Course Category	:	BS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): To provide students the knowledge about gene organization, genetic materials, molecular heritance, gene transfer, and their regulations.

Course Content:

Chemistry of Genetic Material: Discovery of DNA as genetic material, Experiments of Griffith; Avery, McCleod and; McCarthy, and Harshey and Chase. RNA as genetic material- Experiment of Fraenkel and Singer; Nucleic acids: structure of DNA, RNA, and Proteins, DNA Replication in prokaryotes and eukaryotes.

Genome organization: Organization of Prokaryotic and Eukaryotic genome; Fine structure of the Gene: Cistron, muton, and recon; Transformation; Transduction and Conjugation: F factor-mediated, Hfr and F-duction; Introduction to Genomics and Proteomics.

Transposable elements: Transposable elements Maize and Drosophila; Introduction and Types of Gene mutations- Base substitution and Frameshift mutations; Mutagens - Physical and chemical; Reverse mutation in bacteria; DNA repair mechanism (Mismatch

repair photo reactivation, excision and SOS repair); Beneficial and harmful effects of mutations.

Gene Expression and Gene regulation: Genetic code: Brief account. Gene regulation in prokaryotes and eukaryotes, positive regulation, negative regulation, attenuation, gene regulation in lambda phage life cycle, RNA processing and post-transcriptional regulation; regulatory RNA; Eukaryotic transcription factors, enhancers, silencers, insulators, chromatin structure and gene regulation, Translational regulation in prokaryotes and eukaryotes, Post-translational modification and protein stability.

Practicals:

1. Making competent *E. coli* cells using chemical methods.
2. Transformation of *E. coli* and calculation of competence.
3. Cloning and expression of GFP sequence in the expression vector.
4. Extraction of plasmid DNA and calculation of concentration and purity.
5. Extraction of genomic DNA from animal and plant tissues and calculation of concentration and purity.
6. Estimation of size in bp of DNA using agarose gel electrophoresis.
7. Restriction mapping of pUC19 vector.
8. Polyacrylamide gel electrophoresis and estimation of MW of proteins.
9. Extraction of RNA from animal and plant tissues.
10. Preparation of *Drosophila* polytene chromosome squashes

Text Books/References:

1. Lewin's GENES XII by Jocelyn E. Krebs Elliott S. Goldstein and Stephen T. Kilpatrick
2. Molecular Biology of the Gene by James D. Watson, A. Baker Tania, P. Bell Stephen, Gann Alexander, Levine Michael, and Losick Richard
3. The Biophysical Chemistry of Nucleic Acids and Proteins: Thomas E. Creighton; Helvetian Press; 2010.
4. Molecular Cell Biology, 8th edition (2016) by Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon and Kelsey C. Martin
5. Textbook on Molecular Genetics by D. N. Bharadwaj (2009); Kalyani Publisher
6. Latest/classic research articles and reviews relevant to various topics.

Course Outcomes: After completion of the course, students will be able to understand gene organization, genetic materials, molecular heritance, gene transfer, and their regulations.

Course Code	:	BS207
Course Title	:	Biophysics
Number of Credits	:	2 (L: 2, T: 0, P: 0)
Course Category	:	BS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): It is intending to impart basic undergraduate-level knowledge in the area of general Biophysics. The student would be able to understand the molecular and mechanistic basis of the cellular functions, organism physiology, and pathophysiology. They would also be able to assimilate recent research findings, advancement and development in the relevant subject.

Course Content: Biomolecules, Chemical Bonds in Biochemistry, Conformational Changes in DNA Molecules, From DNA to RNA, The Biophysics of RNA, Protein Function, Hierarchical Structure of Proteins, torsional angles in proteins and nucleic acids, Characterization of secondary structure using CD, Protein stability and folding, Thermodynamics of bimolecular structures, Protein folding: thermodynamics and kinetics, Functional Design of Proteins, Electrical Phenomena in Excitable Cells, Electrically Excitable Cells, Electrical Signals of Nerve Cells, The Ionic Hypothesis and Rules of Ionic Electricity, Membrane proteins, Channels and Transporters in Biological system, Functional Properties of Voltage-Gated Ion Channels, Ion pumping and Ion Channel rhodopsins and their use, Cilia and Flagella: Structure and Movement, Molecular Motors: Kinesin, Dynein and Myosin, and intracellular movement, Microtubule structure. Mechanobiology and its importance in human health.

Text Books/References:

1. Biochemistry. 5th edition. Berg JM, Tymoczko JL, Stryer L. New York: W H Freeman; 2002.
2. Basic Neurochemistry: Molecular, Cellular and Medical Aspects. 6th edition. Siegel GJ, Agranoff BW, Albers RW, et al., editors. Philadelphia: Lippincott-Raven; 1999.
3. Molecular Biology of the Cell. 4th edition. Alberts B, Johnson A, Lewis J, et al. New York: Garland Science; 2002.
4. Molecular Cell Biology. 4th edition. Lodish H, Berk A, Zipursky SL, et al. New York: W. H. Freeman; 2000.
5. Neuroscience. 2nd edition. Purves D, Augustine GJ, Fitzpatrick D, et al., editors. Sunderland (MA): Sinauer Associates; 2001.
6. The Biophysics of RNA. *ACS Chem. Biol.* 2007;27440-444

Course Outcomes: After completion of the course, the student would be able to understand the molecular and mechanistic basis of the cellular functions, organism physiology, and pathophysiology.

Course Code	:	BS209
Course Title	:	Cell & Molecular Biology
Number of Credits	:	3 (L: 2, T: 0, P: 2)
Course Category	:	BS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): To provide students the knowledge about cellular content, organization, structures, and functions. To impart a basic understanding of the developmental biology of plants and animals.

Course Content: Microscopy- Visualizing cells and tissues; Integrating cells into tissues (animals and plants); Structure of cell and cell organelles, Details of the cell cycle, cell division and regulation; Cell-Cell junctions; Mitosis and Meiosis.

Gametogenesis (plants and animals), fertilization and embryogenesis, morphogen gradients, differentiation, asymmetric cell division, cell fate and lineage determination; Developmental embryonic stages, zygotic division, incomplete division and consequences; Ecto, meso and endodermal development, neural plate and tube formation; Early asymmetric division and generation of symmetry in developing embryo in animals and plants; organogenesis and morphogenesis, metamorphosis, animal life cycle, sex determination and role of apoptosis in organ development; Role of morphogens and their gradient in axis patterning and determination. Concept of anteroposterior, dorso-ventral, and medio-lateral axis formation. Stem cells, pluripotency, and iPS cells.

Introduction to plant fertilization, ovule and egg, and support cells; Root and shoot development, seed formation (monocot/dicot) and germination; flowering and nonflowering plants; Cellular differentiation and senescence; Meristematic tissue, development of root and leaf and floral tissues

Model organisms like *Drosophila melanogaster*, *C. elegans*, *G. gallus*, *Xenopus*, *Arabidopsis*, etc.;

Practicals

1. Understanding components of different kinds of microscopes.
2. Visualization of mitochondria, plastids, and other intracellular structures.
3. Study of the life cycle of *Drosophila melanogaster*.
4. Study of different stages of chick embryos.
5. In situ hybridization of *Drosophila* embryos to study the cellularization process.
6. Observation of developmental mutants in *Drosophila* and *C. elegans*
7. Study of mitosis in onion root tips
8. Totipotency: Analysis of Growth and Subculture

Text Books/References:

1. Molecular Biology of the Cell: Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walte; 6th edition New York: Garland Science; 2008.
2. Cell and Molecular Biology-Concepts and Experiments; Gerald Karp et al. John Wiley; 8th edition; 2015.
3. Plant Development: The Cellular Basis (1990 edition) by R. F. Lyndon (Publisher- Springer)
4. Topics in Plant Physiology 3. Series editors M. Black and J. Chapman; Unwin Hyman Ltd, 1990.
5. Plant growth and Development: a molecular approach: DE. Fosket; Academic Press 1994.
6. Developmental Biology (12th Edition) by Michael J.F. Barresi and Scott F. Gilbert (Publisher- Sinauer Associates Inc; 2019).

7. Molecular Cell Biology. 4th edition. Lodish H, Berk A, Zipursky SL, et al. New York: W. H. Freeman; 2000.

Course Outcomes: After completion of the course, students will have a basic understanding of the developmental biology of plants and animals.

Course Code	:	BS211
Course Title	:	Plant Biology
Number of Credits	:	2 (L: 1, T: 0, P: 2)
Course Category	:	BS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): To understand plant metabolism, plant development and their interaction with other organisms.

Course Content:

1. Origin of land plants: Earth, Cells and Photosynthesis; Evolution of eukaryotic cells, land plants, seed plants and Angiosperms.
2. Plant cells and genomes: Plant cell structure, the nuclear genome and genome sequencing efforts in model and crop plants. Organelle genomes and gene regulation in the organelles.
3. Plant Metabolism: Control of metabolic pathways. Carbon assimilation: photosynthesis, photorespiration and sucrose transport; Non-photosynthetic generation of energy and precursors. Storage of carbon. Metabolism in plastids. Nitrogen, phosphorus, sulfur and iron assimilation; Movement of water and minerals.
4. Plant Development; Embryo and seed development. Root and shoot development. Transition from vegetative to reproductive phase and from sporophyte to gametophyte.
5. Plant response to environmental signals: Seed germination. Response of plants to light and role of photoreceptors. Response of plants to gravity and root and shoot growth. Signaling during seedling development and flowering. Plant response to environmental biotic and abiotic stress
6. Interactions of plants with other organisms: Microbial pathogens, pests, parasites, viruses and viroid. Defense mechanism in plants. Useful interactions between plants and organisms.
7. Plant domestication and agriculture: The history of plant domestication with specific examples. Scientific plant breeding and role of markers in plant breeding.

Practicals: Practical to be designed by individual centers on the above topics (How many hours and for how many weeks- to be discussed in the meeting).

Text Books/References:

1. Plant Biology. Allison Smith et al. Garland Science, 2010.
2. Botany: An Introduction to Plant Biology, James D. Mauseth.

Course Outcomes: After completion of the course, students will understand about biology of plant development and their interaction with other organisms.

Course Code	:	PS201
Course Title	:	Technical Seminar
Number of Credits	:	1 (L: 0, T: 0, P: 2)
Course Category	:	PS
Continuous Assessment (C.A.)	:	100
End Semester Assessment (E.S.A.)	:	---

Course Objective(s): Develop an ability to understand and present a seminar on the latest scientific and technological developments in the field of engineering and technology which enhances writing as well as oral communication skills.

Guidance / Remarks:

- Seminar in-charges shall highlight the significance of technical seminar in the first two sessions and enlighten the students on the utility of these seminars.
- The student has to identify the related topic.
- The slots, titles shall be decided upfront and seminar in charge shall take signatures.
- The same sheet shall be affixed in the respective classrooms and seminar register.
- If any student fails to present his/her seminar on the given slot, to genuine reasons, they may be asked to present in the subsequent slot/week.
- Progress of the seminars need to be reviewed by the concerned HOD once in 15 days.
- The evaluation for technical seminars has to be informed to students and displayed in the classrooms.
- Report and presentation must contain topic, introduction, explanation, diagrams, tables, applications and conclusions.

SEMESTER IV

Semester IV

Course Code	:	PC202
Course Title	:	Bioprocess Engineering
Number of Credits	:	3 (L: 2, T: 0, P: 2)
Course Category	:	PC
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The Course Objective is to provide basic concepts of bioprocess engineering to the students. They will learn engineering principles that can be applied to processes involving cell or enzyme catalysts with applications in the industry. The students will learn the basics of bioreactor design and operation control that have been applied to a variety of bioprocess industries and also conduct related experiments for better understanding.

Course Content: Microbial growth kinetics, substrate utilization, and product formation kinetics, stoichiometry, principles of enzyme catalysis, enzyme kinetics, immobilized enzymes, bioreactors- batch, fed-batch or continuous bioreactors, Immobilized cell systems, solid-state fermentations, energy balance and mass transfer, operation and control of bioreactors (aeration, agitation, heat transfer, scale-up and scale-down), Bioprocesses for the production of antibiotics, proteins, polysaccharides, aroma etc. Instrumentation and monitoring, sterilization, process modeling, downstream processing, plant/mammalian cell culture reactors, examples of industrial bioprocesses

Case studies on production of antibiotics, enzymes, insulin, bio-ethanol.

Practicals

1. Microbial growth kinetics and estimation of cell mass
2. Growth inhibition kinetics
3. Operation of pH control and dissolved oxygen measurement
4. Enzyme immobilization techniques
5. Bioconversion using immobilized enzyme preparation
6. Aerobic and anaerobic bioconversion process
7. Product formation kinetics in a fermentation process
8. Online analyses of process parameters
9. Effect of mixing and agitation in bioreactors
10. Mass transfer in immobilized cell
11. Estimation of volumetric oxygen transfer coefficient

Text Books/References:

1. Michael Shuler, Fikret Kargi, Matthew DeLisa, Bioprocess Engineering: Basic Concepts, 3rd Edition
2. Pauline Doran, Bioprocess engineering principles
3. Colin Ratledge, Bjorn Kristiansen, Basic Biotechnology, 2nd Edition, Cambridge University Press, 2001.

4. Roger Harrison et al., *Bioseparations Science and Engineering*, Oxford University Press, 2003.
5. *Bioreaction Engineering, Bioprocess Monitoring (Bioreaction Engineering)* by Karl Schügerl

Course Outcomes: At the end of this course, the students will learn the basics of bioprocess engineering and learn the principle, design, and operation control of various types of bioreactors and their scale-up strategies.

Course Code	:	PC204
Course Title	:	Green Biotechnology and Pollution Abatement
Number of Credits	:	2 (L: 2, T: 0, P: 0)
Course Category	:	PC
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The course content aims to make the student understand how biotechnology can help in monitoring or removing the pollutants and developing an understanding of new trends such as biofuels, renewable energy sources, or development of stress-tolerant plants which can minimize the harmful impact of pollutants thereby making the planet earth a better dwelling place.

Course Content: Biological Waste Treatment: Biological wastewater treatment: Principles and design aspects of various waste treatment methods with advanced bioreactor configuration: Solid waste management: landfills, recycling and processing of organic residues, minimal national standards for waste disposal.

Biodegradation of Xenobiotic Compounds: Xenobiotic compounds–Definition, examples and sources. Biodegradation- Introduction, effect of chemical structure on biodegradation, recalcitrance, co metabolism and biotransformation. Factors affecting biodegradation, microbial degradation of hydrocarbons.

Biotransformations and Biocatalysts: Basic organic reaction mechanism- Common prejudices against enzymes, advantages & disadvantages of biocatalysts, isolated enzymes versus whole cell systems, biocatalytic application, catalytic antibodies; stoichiometry.

Bioremediation and Biore Restoration: Introduction and types of bioremediation, bioremediation of surface soil and sludge, bioremediation of subsurface material, In situ and Ex-situ technologies, phytoremediation- restoration of coal mines a case study. biore restoration: reforestation through micropropagation, use of mycorrhizae in reforestation, use of microbes for improving soil fertility, reforestation of soils contaminated with heavy metals.

Eco-Friendly Bioproducts from Renewable Sources: Fundamentals of composting

process: scientific aspects and prospects of biofuel production: bioethanol, biohydrogen and biodiesel; biofertilizers and biopesticides.

Biotechnology in Environment Protection: Current status of biotechnology in environment protection and its future, release of genetically engineered organisms in the environment.

Text Books/References:

1. Environmental Processes I-III, J. Winter, 2nd ed., Wiley Publications
2. Introduction to Wastewater Treatment- R. S. Ramalho, Academic Press.
3. Elements of Water Pollution Control Engineering – O.P. Gupta, Khannabooks.
4. Energy Technology – O.P. Gupta, Khannabooks, 2018.
5. Bharucha Erach, The Biodiversity of India, Mapin Publishing Pvt. Ltd.
6. Environmental Biotechnology, B.C. Bhattacharya & Ritu Banerjee, Oxford Press, 2007.
7. Environmental Biotech, Pradipta Krimar, I.K. International Pvt. Ltd., 2006.
8. Environmental Microbiology & Biotechnology, D.P. Singh, S.K. Dwivedi, New Age International Publishers, 2004.
9. Biodegradation and Bioremediation 1999 (2nd edition). Martin Alexander, Elsevier Science & Technology.
10. Environmental Biotechnology by Bruce Rittmann and Perry McCarty.

Course Outcomes: Students will gain knowledge about how to maintain the environment. They will also gain the knowledge to use biotechnology for waste management, bioremediation, and green energy.

Course Code	:	PC206
Course Title	:	Immunology & Immuno-technology
Number of Credits	:	3 (L: 2, T: 0, P: 2)
Course Category	:	PC
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): This course will introduce the students with basic principles of immunology and recent advancements in the field of adaptive immunity.

Course Content: Immune cell types, Hematopoiesis, B and T lymphocytes, NK cells, Lymphoid organs (primary and secondary), Features of/introduction to inflammation, Humoral immunity/Cell-mediated immunity, Pro-inflammatory and anti-inflammatory cytokines, Innate Immune system, cell polarization/activation (classical/alternate), Adaptive immune system, Antibody structure, Generation of antibody diversity, (Somatic hyper mutation), Major histocompatibility complex, Antigen presentation, APCs, Germinal center, Plasma Cells, BCR signaling, B-cell maturation/activation, T-cell development, negative/positive selection, TCR rearrangement, co-stimulatory molecules. T cell subtypes: Th1, Th2, Th17, Tregs etc. Vaccines, memory B and T cell responses,

active immunization, passive immunization. Immunity without infection (autoimmunity, hypersensitivity, host vs graft reaction).

Immune checkpoints: PD1, CTLA4, TIM3 etc. Design of recombinant antibodies, Commercial production of polyclonal and monoclonal antibodies, Antibodies in diagnostics, Immuno-therapy in cancer, checkpoint therapy, Vaccine production, Plant immunology.

Immunological techniques: Immuno-diffusion assay, ELISA, Immuno-blotting, ELISPOT assay, Immuno-Histochemistry, Flow Cytometry, FACS sorting, Immuno-precipitation.

Practicals:

1. Western blotting
2. Isolation and microscopic visualization of T-cells and B-cells
3. Use a commercially available immune diagnostic strip tests
4. Immuno-precipitation of a protein from cell lysate using antibody
5. Determination of binding affinity of antigen-antibody complex
6. Demonstration of ELISA
7. Demonstration of FACS

Text Books/References:

1. Kuby Immunology by Thomas J. Kindt, Barbara A. Osborne, Richard Goldsby.
2. Principles of Microbiology and Immunology by Harper and Row.
3. Introduction to Medical Immunology by Gabriel Virella.

Course Outcomes: Students will gain knowledge about the immune system, cell types and its pathway. They will understand the role of the immune system in disease conditions. Further, they will gain knowledge about the generation of antibodies and the use of antibodies in analytics, diagnostics, and therapy.

Course Code	:	PC208
Course Title	:	rDNA Technology
Number of Credits	:	3 (L: 2, T: 0, P: 2)
Course Category	:	PC
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): It is intended to impart basic undergraduate-level knowledge in the area of molecular biology and recombinant DNA technology. The student would be able to understand the working details of the cloning of a gene. They would also be able to assimilate recent research findings, advancement and development in the relevant subject. The use of virtual lab and computational tools would enable them to perform *in silico* cloning of the selected DNA.

Course Content: Introduction to recombinant DNA technology and its uses, Vectors: cloning, expression, and promoter less vectors, Cloning and expression of bacterial host strain. Restriction enzymes, Ligase, other important DNA modifying enzymes (e.g. CIAP) and their use in recombinant DNA technology. Tools for gene Identification and Isolation

including PCR based methods. Amplification of DNA using PCR, Selection of restriction sites (Restriction digestion analysis of target DNA) for cloning of an amplified DNA into selected vector (cloning/expression), Preparation of bacterial competent cells, Transformation of ligated (recombinant) DNA in selected host (e.g. Bacterial host), Screening of recombinant bacterial colonies using colony PCR, restriction digestion analysis of the recombinant DNA, sequencing of the recombinant DNA and expression of the recombinant DNA (expression construct) into a suitable host, Purification and selected characterization (spectroscopic) of the purified recombinant proteins. Discuss possible troubleshoots. Genomic and cDNA library? Site directed mutagenesis? RNA isolation and RT-PCR.

Practical Exercise:

Repeat

- Preparation of competent cells,
- Transformation of the selected plasmid (high copy number),
- Isolation of the plasmid from bacterial culture (alkali lysis methods),
- Restriction digestion of the plasmids and analysis using DNA gel and extraction of plasmid DNA from the gel using glass wool methods.
- PCR amplification and ligation
- Selection of transformed E. coli and validation of cloning
- RNA isolation and RT PCR and their analysis.

Text Books/References:

1. Principles of Gene Manipulation and Genomics, Primrose & Twyman.
2. Winnacker, Ernst L. (1987), From genes to clones: introduction to gene technology [Gene und Klone] (in German), Horst Ibelgaufts (trans.), Weinheim, New York: VCH, ISBN 0-89573-614-4.
3. Modern Genetic Analysis. Griffiths AJF, Gelbart WM, Miller JH, et al. New York: W. H. Freeman; 1999.
4. Molecular Cloning - Sambrook Russel - Vol. 1, 2, 3.
5. Molecular Biology of the Cell. 4th edition. Alberts B, Johnson A, Lewis J, et al. New York: Garland Science; 2002.

Course Outcomes: Students will gain knowledge about the use and applications of recombinant DNA technology in different sectors like health, agriculture, and the environment. Students will also gain knowledge about the safety and ethical use of rDNA technology.

Course Code	:	PC210
Course Title	:	Structural Biology
Number of Credits	:	3 (L: 2, T: 1, P: 0)
Course Category	:	PC
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): This course focuses on relating theoretical concepts and experimental approaches to a wide range of potential research problems in the area of structural biology. The course aims to provide a solid foundation of understanding structural biology that will facilitate application to current and future research problems.

Course Content:

Protein structural biology: Protein sequences, sequence alignment; basic polypeptide stereochemistry, hierarchy in protein folds: secondary structure, tertiary structure, quaternary structure. Chaperones assisted protein production, Thermodynamics of protein stability. Effect of amino acid on protein structure.

Protein structure and analysis: Principles of soluble and membrane protein purification, Phase diagram and separation, crystallization, Use of robotics in crystallization, Space groups and symmetry, structure determination; NMR sample preparation, Sample preparation for Cryo EM, Structure validation and best practices on the use of protein structures from protein data bank; Protein fold-function relationships, Protein Data Bank (PDB) and EM Data Bank, BioMagResBank (BMRB).

Methods for atomic-resolution structure determination: X-ray crystallography, solution- and solid-state NMR spectroscopy, Single particle Cryo Electron Microscopy, X-Ray Free-Electron Laser (XFEL). Anisotropy? Use of Circular Dichroism, Steady-state and time-resolved fluorescence spectroscopy, FRET, Single molecule fluorescence, Electron Paramagnetic Resonance spectroscopy.

DNA and RNA structures: DNA and RNA secondary structures (duplex, triplex, quadruplexes and aptamers), RNA secondary structure prediction.

Structure of Sugars and lipids

Structural dynamics: Dynamics of Protein-RNA complexes; Structure and organization of genomes.

Simulations: Protein functional dynamics, Protein dynamics studies by MD simulations; Protein dynamics studies by biophysical techniques.

Text Books/References:

1. Biophysical Chemistry vol I, II and III by Charles R. Cantor and Paul R. Shimmel.
2. Structure and Mechanism in Protein Science by Alan Fersht.
3. Proteins: Structures and Molecular Properties, by Thomas E. Creighton.
4. Introduction to Protein Structure by Branden and Tooze, Garland Science; 2nd edition 1999.
5. Principles of nucleic acid structure, by Stephen Neidle.
6. RNA Sequence, Structure, and Function: Computational and Bioinformatic Methods by Walter L. Ruzzo, Jan Gorodkin, Springer 2014.
7. Crystallography made crystal clear by Gale Rhodes.
8. NMR of Proteins and Nucleic Acids by Kurt Wüthrich.
9. The Art of Molecular Dynamics Simulation by D. C. Rapaport Cambridge University Press; 2nd edition 2004.

Course Outcomes: Students will gain an understanding of the basic science of Protein and Nucleic Acid (DNA and RNA) structure, including first principles of physical interactions that maintain proteins and the mechanisms that make them intact. They will also learn about the different techniques and experimental approaches that represent the state-of-the-art and are widely used in the study of proteins. The final session of the course will deal with different applications of protein structure. Importantly, with the Structural Biology course, the students will be offered a learning environment that should make the understanding of protein structure and its dynamics interesting, reachable and relevant to their future careers.

Course Code	:	PC212
Course Title	:	Bioinformatics & Computational Biology
Number of Credits	:	3 (L: 2, T: 0, P: 2)
Course Category	:	PC
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): This course is beneficial for students to understand the principles of analyzing biological data, building models and testing hypotheses using computer science algorithms. This course is a survey of algorithms and tools in biological sequence analysis, genome-wide disease association, and precision medicine. Basic concept machine learning and its application in the analysis of biological data are also included in this course. It will also introduce information technology practices in the field of biotechnology. The course will provide a basic overview of various information repositories widely used in biological sciences; and tools for searching or querying those databases. This course will build the foundation of sequence alignment techniques and find evolutionary connections. It will help students to analyze mRNA expression data and gene annotations.

Course Content:

Theory:

General Introduction: To study bioinformatics and its applications.

Biological databases and tools: Nucleotide sequence databases, Protein sequence, structural and functional databases, Patent database, *in silico* tools for rDNA technology.

Database searching: BLAST and its types, Entrez, Ensembl-Biomart.

Pairwise Sequence alignment: Pairwise alignment, Dynamic programming, Scoring Matrices, Gaps.

Multiple sequence alignment: Dynamic and heuristic methods, Relevance to inferences about evolution, introduction to molecular phylogeny.

Phylogenetic analysis: Introduction, Types of Phylogenetic Trees, Methods and Applications. Bootstrap.

Genome informatics: Genome sequencing technologies and analysis methods; transcription factor regulation and motif finding.

Computational Epigenetics: Epigenetics and its role in transcription regulation, development, and diseases.

Genomic variations and its associations: Linking genes, variations and diseases; Introduction to biomarkers and personalized medicine.

Network biology and human diseases: Genome-wide association studies of human diseases, Genome editing tools and applications to human diseases.

Machine learning: Classification, Regression, SVM, Decision Trees, Artificial Neural Networks, Big Data in Biology.

Molecular modeling (Homology and *Ab initio*) and validation (Procheck, verify 3D etc), Docking, Molecular dynamics, Energy calculations,

Classical and semi-classical calculations, Quantum mechanical approaches

Practicals:

1. Finding patterns in genomes.
2. Implementation of motif finding algorithms.
3. Identifying various regions around genes using Genome browsers
4. Browsing genetic variation databases such as dbSNP, ClinVar.
5. Finding disease variation association using GWAS Catalog.
6. Basic machine learning using WEKA tool.
7. Accessing databases from NCBI.
8. Extracting protein and nucleotide sequences from NCBI.
9. Database Search Tools.
10. Similarity search using BLAST.
11. Pairwise sequence alignment.
12. Multiple sequence alignment.
13. Conserved domain analysis.
14. Construction of Phylogenetic trees.

Text Books/References:

1. Jonathan Pevsner. Bioinformatics and Functional Genomics, 2nd Edition. ISBN: 978-0-470-08585-1.
2. Greg Gibson and Spencer V. Muse. A Primer of Genome Science, Third Edition. ISBN: 978-0-87893-309-9.
3. Essential Bioinformatics, Jin Xiong, Cambridge University Press; 1st edition 2006.
4. Bioinformatics: methods and applications, S. C. Rastogi, PHI learning; 4th edition, 2013.
5. The Dictionary of Genomics, Transcriptomics and Proteomics, Günter Kahl, Willey VCH, 2015.

Course Outcomes: After completing this course, students will perform computational analyses of biological sequences, genome-wide studies and relate the results to core principles of biology; use computational methods to help execute a biological research plan; analyze biological problems and data using the latest machine learning and deep learning techniques. By the end of this course students can browse or retrieve gene, protein sequences and related information from biological databases; learn to align sequences using dot matrices, dynamic programming and heuristic approach; understand the notion of similarity, identity, and gaps in the context of sequence alignment and deduce evolutionary relationships among sequences; analyze microarray and RNA-seq gene expression data.

Course Code	:	AU202
Course Title	:	Environmental Science
Number of Credits	:	0 (L: 2, T: 0, P: 0)
Course Category	:	AU
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): People working in industries or elsewhere essentially require the knowledge of environmental science to enable them to work and produce the most efficient, economical and eco-friendly finished products.

- Solve various engineering problems applying ecosystem to produce eco – friendly products.
- Use relevant air and noise control method to solve domestic and industrial problems.
- Use relevant water and soil control method to solve domestic and industrial problems.
- To recognize relevant energy sources required for domestic and industrial applications.
- Solve local solid and e-waste problems.

Course Content:

Unit-1: Ecosystem

- Structure of ecosystem, Biotic & Abiotic components.
- Food chain and food web.
- Aquatic (Lentic and Lotic) and terrestrial ecosystem.
- Carbon, Nitrogen, Sulphur, Phosphorus cycle.
- Global warming -Causes, effects, process, Green House Effect, Ozone depletion.

Unit-2: Air and Noise Pollution

- Definition of pollution and pollutant, Natural and man-made sources of air pollution (Refrigerants, I.C., Boiler).
- Air Pollutants: Types, Particulate Pollutants: Effects and control (Bag filter, Cyclone separator, Electrostatic Precipitator).
- Gaseous Pollution Control: Absorber, Catalytic Converter, Effects of air pollution due to Refrigerants, I.C., Boiler.
- Noise pollution: sources of pollution, measurement of pollution level, Effects of Noise pollution, Noise pollution (Regulation and Control) Rules, 2000.

Unit-3: Water and Soil Pollution

- Sources of water pollution, Types of water pollutants, Characteristics of water pollutants Turbidity, pH, total suspended solids, total solids BOD and COD: Definition, calculation.
- Wastewater Treatment: Primary methods: sedimentation, froth floatation, Secondary methods: Activated sludge treatment, Trickling filter, Bioreactor, Tertiary Method: Membrane separation technology, RO (reverse osmosis).

- Causes, Effects and Preventive measures of Soil Pollution: Causes-Excessive use of Fertilizers, Pesticides and Insecticides, Irrigation, E-Waste.

Unit- 4: Renewable sources of Energy

- Solar Energy: Basics of Solar energy. Flat plate collector (Liquid & Air). Theory of flat plate collector. Importance of coating. Advanced collector. Solar pond. Solar water heater, solar dryer. Solar stills.
- Biomass: Overview of biomass as an energy source. Thermal characteristics of biomass as fuel. Anaerobic digestion. Biogas production mechanism. Utilization and storage of biogas.
- Wind energy: Current status and future prospects of wind energy. Wind energy in India. Environmental benefits and problem of wind energy.
- New Energy Sources: Need of new sources. Different types of new energy sources. Applications of (Hydrogen energy, Ocean energy resources, Tidal energy conversion.) Concept, origin and power plants of geothermal energy.

Unit-5: Solid Waste Management, ISO 14000 & Environmental Management

- Solid waste generation- Sources and characteristics of: Municipal solid waste, E-waste, biomedical waste.
- Metallic wastes and Non-Metallic wastes (lubricants, plastics, rubber) from industries. Collection and disposal: MSW (3R, principles, energy recovery, sanitary landfill), Hazardous waste.
- Air quality act 2004, air pollution control act 1981 and water pollution and control act 1996. Structure and role of Central and state pollution control board.
- Concept of Carbon Credit, Carbon Footprint.
- Environmental management in fabrication industry.
- ISO14000: Implementation in industries, Benefits.

Text Books/References:

1. S.C. Sharma & M.P. Poonia, Environmental Studies, Khanna Publishing House, New Delhi.
2. C.N. R. Rao, Understanding Chemistry, Universities Press (India) Pvt. Ltd., 2011.
3. Arceivala, Soli Asolekar, Shyam, Waste Water Treatment for Pollution Control and
4. Reuse, Mc-Graw Hill Education India Pvt. Ltd., New York, 2007, ISBN:978-07-062099-
5. Nazaroff, William, Cohen, Lisa, Environmental Engineering Science, Willy, New York, 2000, ISBN 10: 0471144940.
6. O.P. Gupta, Elements of Environmental Pollution Control, Khanna Publishing House, New Delhi
7. Rao, C. S., Environmental Pollution Control and Engineering, New Age International Publication, 2007, ISBN: 81-224-1835-X.
8. Rao, M. N.Rao, H.V.N, Air Pollution, Tata Mc-Graw Hill Publication, New delhi, 1988, ISBN: 0-07- 451871-8.
9. Frank Kreith, Jan F. Kreider, Principles of Solar Engineering, McGraw-Hill, New York; 1978, ISBN: 9780070354760.
10. Aldo Vieira, Da Rosa, Fundamentals of renewable energy processes, Academic Press Oxford, UK; 2013. ISBN: 9780123978257.
11. Patvardhan, A.D, Industrial Solid Waste, Teri Press, New Delhi, 2013, ISBN:978-81-7993-502-6

12. Metcalf & Eddy, Waste Water Engineering, Mc-Graw Hill, New York, 2013, ISBN: 077441206.
13. Keshav Kant & Rajni Kant, Air Pollution & Control, Khanna Publishing House, New Delhi (Edition 2018)

Open source software and website address:

1. www.eco-prayer.org
2. www.teriin.org
3. www.cpcp.nic.in
4. www.cpcp.gov.in
5. www.indiaenvironmentportal.org.in
6. www.whatis.techtarget.com
7. www.sustainabledevelopment.un.org
8. www.conserve-energy-future.com

Teachers should use the following strategies to achieve the various outcomes of the course.

- Different methods of teaching and media to be used to attain classroom attention.
- Massive open online courses (MOOCs) may be used to teach various topics/subtopics.
- 15-20% of the topics which are relatively simpler or descriptive in nature should be given to the students for self-learning and assess the development of competency through classroom presentations.
- Micro-projects may be given to a group of students for hands-on experiences.
- Encouraging students to visit sites such as Railway station and research establishment around the institution.

Course Outcomes: At the end of the course student will be able to

1. Understand the ecosystem and terminology and solve various engineering problems applying ecosystem knowledge to produce eco – friendly products.
2. Understand the suitable air, extent of noise pollution, and control measures and acts.
3. Understand the water and soil pollution, and control measures and acts.
4. Understand different renewable energy resources and efficient process of harvesting.
5. Understand solid Waste Management, ISO 14000 & Environmental Management.

Course Code	:	HS202
Course Title	:	Engineering Economics
Number of Credits	:	2 (L: 2, T: 0, P: 0)
Course Category	:	HS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s):

1. This course aims at providing the student with advanced concepts of engineering economic analysis and its role in engineering decision making.

2. Additionally, the course also covers topics such as depreciation, after tax analysis, replacement analysis, uncertainty, inflation, deflation, and estimation of future events.

Course Content:

- **Introduction:** Definition – Nature – Scope and Significance of Economics for Engineers.
- **Demand and Supply:** Demand – Types – Determinants – Law of Demand – Elasticity of Demand – Types – Significance – Supply – Market price determination – Case Study in Demand Forecasting -- Meaning – Methods – Consumer Survey – Trend Projections – Moving average.
- **Cost and Revenue:** Concepts – Classifications – Short run and long run cost curves – Revenue – Concepts – Measurement of Profit (Case Study).
- **Market Structure:** Perfect Competition – Characteristics – Price and output determination in short run and long run – Monopoly – Price Discrimination – Monopolistic Competition – Product Differentiation – Oligopoly and Duopoly.
- **Market Failure:** Causes – Type of Goods – Rivalrous and Non-rivalrous goods – Excludable and Non-excludable goods – Solutions – Government Intervention.
- **Money and Banking:** Money – Functions – Quantity theory of money – Banking – Commercial Banks – Functions – Central Bank (RBI) – Functions – Role of Banks in Economic Development.
- **Foreign Exchange:** Balance of Payments – Exchange rate determination – Methods of foreign payments – International Institutions – IMF, IBRD.
- **Business Cycle and National Income:** Meaning – Phases of business cycle - Inflation – Causes – Control measures - Deflation - National Income – Concepts – Methods of calculating national income – Problems in calculating national income.

Text Books:

1. Premvir Kapoor, "Sociology & Economics for Engineers", Khanna Publishing House, 2018.
2. Dewett. K.K., Navalur M. H., "Modern Economic Theory", S. Chand and Company Ltd, New Delhi, 24thEdn., 2014.
3. Lipsey & Chrystal, "Economics", Oxford University Press, 2010.

References:

1. Paul A Samuelson & William, "Economics", Tata McGraw Hill, New Delhi, 2012.
2. Francis Cherinullem "International Economics", McGraw Hill Education, 2011.
3. William A McEachern and Simrit Kaur, "Micro ECON", Cengage Learning, 2013.
4. William A McEachern and Indira A., "Macro ECON", Cengage Learning, 2014.

Course Outcome(s):

1. Describe the role of economics in the decision making process and perform calculations in regard to interest formulas.
2. Estimate the Present, annual and future worth comparisons for cash flows.
3. Calculate the rate of return, depreciation charges and income taxes.
4. Enumerate different cost entities in estimation and costing.

5. Explain the importance of finance functions, financial ratios and solve related problems.
6. Explain the elements of budgeting and benchmarking.

Course Code	:	PS202
Course Title	:	Comprehensive <i>viva voce</i>
Number of Credits	:	1 (L: 0, T: 0, P: 2)
Course Category	:	PS
Continuous Assessment (C.A.)	:	100
End Semester Assessment (E.S.A.)	:	---

Course Objective(s):

S. No.	Description	Marks
1	First mid-sessional viva at the end of 5 weeks (Internal)	12.5
2	Second mid-sessional viva at the end of 10 weeks (Internal)	12.5
3	Final viva during practical examinations (External)	75.0
Total		100

Guidance/Remarks:

- There shall be comprehensive viva voce as stated above which will be evaluated for 100 marks. Out of 100 marks, 25 marks are internal and 75 marks are external.
- The evaluation of comprehensive viva-voce has to be carried out by two teachers independently and average be taken.
- The sessional marks awarded by the Department are not final. They are subject to scrutiny by a committee constituted by the college and scaling is done wherever necessary.
- The recommendations of the Committee are final and binding.

SEMESTER V

Semester V

Course Code	:	HS301
Course Title	:	Entrepreneurship & Startups
Number of Credits	:	2 (L: 1, T: 1, P: 0)
Course Category	:	HS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s):

1. Acquiring Entrepreneurial spirit and resourcefulness.
2. Familiarization with various uses of human resource for earning dignified means of living.
3. Understanding the concept and process of entrepreneurship - its contribution and role in the growth and development of individuals and the nation.
4. Acquiring entrepreneurial quality, competency, and motivation.
5. Learning the process and skills of creation and management of entrepreneurial venture.

Course Content:

Unit 1: Introduction to Entrepreneurship and Start – Ups

- Definitions, Traits of an entrepreneur, Intrapreneurship, Motivation
- Types of Business Structures, Similarities/differences between entrepreneurs and managers.

Unit 2: Business Ideas and their implementation

- Discovering ideas and visualizing the business
- Activity map
- Business Plan

Unit 3: Idea to Start-up

- Market Analysis – Identifying the target market,
- Competition evaluation and Strategy Development,
- Marketing and accounting,
- Risk analysis

Unit 4: Management

- Company’s Organization Structure,
- Recruitment and management of talent.
- Financial organization and management

Unit 5: Financing and Protection of Ideas

- Financing methods available for start-ups in India
- Communication of Ideas to potential investors – Investor Pitch
- Patenting and Licenses

Unit 6: Exit strategies for entrepreneurs, bankruptcy, and succession and harvesting strategy.

Text Books/References:

S. No.	Title of Book	Author	Publication
1	The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company	Steve Blank and Bob Dorf	K & S Ranch ISBN - 978-0984999392
2	The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses	Eric Ries	Penguin UK ISBN - 978-0670921607
3	Demand: Creating What People Love Before They Know They Want It	Adrian J. Slywotzky with Karl Weber	Headline Book Publishing ISBN - 978-0755388974
4	The Innovator's Dilemma: The Revolutionary Book That Will Change the Way You Do Business	Clayton M. Christensen	Harvard business ISBN: 978-142219602

Websites:

1. <https://www.fundable.com/learn/resources/guides/startup>
2. <https://corporatefinanceinstitute.com/resources/knowledge/finance/corporate-structure/>
3. <https://www.finder.com/small-business-finance-tips>
4. <https://www.profitbooks.net/funding-options-to-raise-startup-capital-for-your-business/>

Course Outcomes: Upon completion of the course, the student will be able to demonstrate knowledge of the following topics:

1. Understanding the dynamic role of entrepreneurship and small businesses
2. Organizing and Managing a Small Business
3. Financial Planning and Control
4. Forms of Ownership for Small Business
5. Strategic Marketing Planning
6. New Product or Service Development
7. Business Plan Creation

Course Code	:	PC301
Course Title	:	Metabolic Engineering
Number of Credits	:	3 (L: 2, T: 0, P: 2)
Course Category	:	PC
Continuous Assessment (C.A.)	:	25

End Semester Assessment (E.S.A.)	:	75
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Course Objective(s): The course will provide an overview of the basic concepts and experimental techniques used in metabolic engineering and its applications in production of useful compounds of industrial importance. The students will also learn that how complex regulatory mechanisms at multiple levels control the dynamics of the cellular metabolism. The course will also cover examples of successful engineering strategies used for the production of commercially important primary and secondary metabolites or recombinant proteins.

Course Content:

Module 1: Introduction to metabolic engineering and its importance:

Introduction to metabolism, catabolism, anabolism. Key differences between metabolic controls of prokaryotes and eukaryotes. Stoichiometry of cellular reactions, enzyme kinetics, reaction rates, dynamic mass balance, yield coefficients and linear rate equations, the black box model, elementary balance, heat balance different models for cellular Reactions-Induction-Jacob Monod Model and its regulation, differential regulation by isoenzymes, concerted or cumulative feedback regulation. Regulation in branched pathways, permeability and transport of metabolites.

Module 2: Metabolic flux analysis:

Building stoichiometric matrix; Steady state and pseudo steady state assumptions; Using different optimizing functions to solve linear programming problem; understanding flux cone and constraints; Introducing additional constraints from thermodynamics;

Module 3: Experimental determination of metabolic fluxes

C13 labeling, NMR and GC-MS based methods for flux determination.

Module 4: Computational modelling of biological networks:

Introduction to MATLAB. Synthetic circuit design, metabolic flux analysis. MOMA (Minimization of Metabolic Adjustment), iFBA (Integrated Flux Balance Analysis), dFBA; Enhancement of product yield and productivity.

Module 5: Industrial applications

pathway engineering strategies for overproduction of some commercially important primary and secondary metabolites (e.g. amino acids, organic acids, alcohols and therapeutic compounds) or industrially relevant enzymes and recombinant proteins, bioconversion- applications and factors affecting bioconversion, mixed or sequential bioconversions, regulation of enzyme production, strain selection and improvement, the modification of existing or the introduction of entirely new metabolic pathways

Practicals

- Develop engineering strategies to boost production of industrially relevant compound in *E. coli*.
- Strain engineering (deletion or overexpression of genes) to boost production of target compound followed by metabolite extraction and quantification.
- Demonstration of feed-back regulation and product inhibition
- Development of a flux model and correlation of the model with experimental data.

Text Books/References:

1. Metabolic Engineering: Principles and Methodologies by Gregory N. Stephanopoulos, Aristos A. Aristidou, and Jens Nielsen.
2. Pathway Analysis and Optimization in Metabolic Engineering by Néstor V. Torres and Eberhard O. Voit.
3. The Metabolic Pathway Engineering Handbook by Christina D. Smolke.
4. Biochemical Engineering by Harvey W. Blanch and Douglas S. Clark.

Course Outcomes: At the end of this course, the students will learn and systematically analyze the complexities defining the regulation of various metabolic pathways. They will be able to design and learn strain-engineering strategies to alter cellular behavior, metabolic flux, and product formation. They will also appreciate the vast industrial applications of metabolic engineering in the field of medicine, energy, and environment.

Course Code	:	PC303
Course Title	:	Analytical Techniques
Number of Credits	:	3 (L: 2, T: 0, P: 2)
Course Category	:	PC
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): To learn different modern analytical techniques used in biotechnology.

Course Content:

Light spectroscopy and Microscopy-Absorption, IR, Scattering (Raman and Rayleigh), Resonance Raman, Fluorescence (steady-state and time resolved), confocal microscopy, Multi-photon microscopy, Atomic Force Microscopy, Chromatography-Ion-Exchange, Affinity, Hydrophobic, Size exclusion, FPLC, HPLC, GC. Ultracentrifugation, Electrophoresis, Solution- and solid-state NMR spectroscopy, X-ray crystallography, Mass spectroscopy-MALDI, LC-MS, GC-MS, MS-MS, MALDI-Mass imaging, Proteomics, MS and NMR based Metabolomics, DNA and RNA sequencing for genomics, PCR for transcriptomic, Real time PCR, Droplet PCR, Calorimetry, Surface Plasmon Resonance (SPR), Bio-layer interferometry (BLI), High content screening.

Practicals

1. Measurement of IR and Raman spectra of small molecules
2. Measurement of excitation and emission spectra of a fluorophore and their wavelengths for maximum excitation and emission
3. Purification of a compound from a mixture using HPLC
4. Protein purification using affinity, ion-exchange and gel filtration chromatography
5. Analysis of NMR spectra and structure determination of a bio-active compound like cyclosporine.
6. Analysis of SPR and ITC data and calculation of binding affinities.
7. Demonstration of analysis of genomics data

Text Books/References:

1. Biophysical Chemistry, Vol II by Charles R. Canter and Paul R. Shimmel.
2. Protein Purification: Principles and Practice by Robert K. Scopes (Narosa).
3. Principles of Fluorescence Spectroscopy by Joseph R. Lakowicz.
4. Infrared Spectroscopy Fundamentals and Applications by Barbar Stuart.
5. Raman Spectroscopy for Chemical Analysis by RICHARD L. McCREERY.
6. NMR spectroscopy by Harald Gunther (John Wiley).
7. Mass Spectrometry Basics by Christopher G. Herbert and Robert W. Johnstone.
8. Chromatographic methods by A Braithwaite and F. J. Smith (Kluwer Academic Publishers).

Course Outcomes: At the end of the course, student would be able to understand and apply modern analytical techniques used in biotechnology.

Course Code	:	PC305
Course Title	:	Cheminformatics & Medicinal Chemistry
Number of Credits	:	3 (L: 2, T: 0, P: 2)
Course Category	:	PC
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): This course for biotechnology students introduces the small-molecule-ligand-oriented *in silico* Physico-chemical aspects of rational drug design. Topics include *in silico* representation of chemical information, chemical databases and data mining, molecular drawing and interactive visualization, computer-aided drug design, building a ligand *ab initio* or from similar ligands, with and without known macromolecules, assessing activity and toxicity and drugability.

Course Content

Chemistry & Information technology: Overview of Rational Drug Design, Ligands and Targets, *in-silico* representation of chemical information.

Chemical Databases: Data Mining, Chemical/biochemical data collation, retrieval, analysis & interpretation.

Molecular Drawing and Interactive Visualization: Building molecules on a computer, Molecular Modeling.

Computer-Aided Drug Design: Overview, Structural Homology Modeling Tools, Docking Tools and Screening Tools

Chemical data science: Artificial intelligence in chemistry, Simulation methods for molecules and materials.

Stereochemistry and mechanism, coordination chemistry for drug design, *in silico* tools for medicinal chemistry (docking, MD, *de novo* drug design), Organic reaction mechanism, Logic in organic synthesis, QSAR, pharmacological screening, chemistry of drug action, Pharmaceutical Preformulation, Solid State Pharmaceuticals, Drug metabolism, pharmacokinetics, pharmacodynamics.

Practicals

1. *in silico* selection of compound from an NCI library against a target protein.
2. Docking, energy minimization and MD simulation of Cyclosporine-CyclophilinA complex
3. Structure based drug design against a target protein such HIV-1 protease using crystal structure from Protein Data Bank
4. Analysis of PK and PD data of a drug candidate
5. Organic synthesis of a stereo-selective small compound and its purification

Text Books/References:

1. Muthukumarasamy Karthikeyan and Renu Vyas. Practical chemoinformatics. Springer, soft-cover ISBN 9788132234913, 2014.
2. Silverman, Richard B., and Mark W. Holladay. The organic chemistry of drug design and drug action. Academic Press, 2014.
3. Bajorath, Jurgen. Chemoinformatics for Drug Discovery. John Wiley & Sons, 2013.
4. Cramer, C.J., Essentials of Computational Chemistry, 2nd Ed., John Wiley & Sons Ltd., 2004.
5. Essentials of Foye's Principles of Medicinal Chemistry – 2016.
6. An Introduction to Medicinal Chemistry, by Graham L. Patrick.
7. Medicinal Chemistry by Ashutosh Kar.

Course Outcomes: By the end of this course, students will able to investigate chemicals and materials that are not practical for laboratory analysis; develop individual model molecules or the behaviors of chemical compounds within the natural world; create and/or work with databases to catalog, categorize, organize, and search the structures of chemicals; employ computational chemistry to simplify problems and make calculations that are used in laboratory experimentation.

Course Code	:	PC307
Course Title	:	Good Manufacturing and Laboratory Practice
Number of Credits	:	3 (L: 2, T: 1, P: 0)
Course Category	:	PC
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): Basic understanding of the regulatory requirement of cGMP and GLP.

Course Content: Introduction to Good Manufacturing and Laboratory Practice, Requirement of GLP and GMP compliance for regulatory approval, Ethics in manufacturing and control, Principles of quality by design (QBD) Introduction to the concept of Design of Experiment (DOE) Application of QBD principles in Biotech product development. Case studies: Example of QBD and DOE in Process Development, Example of DOE in analytical development, Introduction to ICH guidelines and their usage, National and international regulatory authorities and their function, Pharmaceutical Jurisprudence and Laws related to Product design, Drug Development & Approval Process, Regulation of Clinical and Preclinical Studies, Good Manufacturing Practices, Formulation Production Management, Authorization and marketing of drugs.

Computer simulation on process design.

Text Books/References:

1. cGMP starter guide: Principles in Good Manufacturing Practices for Beginners, Emmet P. Tobin, Createspace Independent Publishing Platform, April 2016.
2. Good Manufacturing Practices for Pharmaceuticals: GMP in Practice, B Cooper, Createspace Independent Publishing Platform, July 2017.
3. Sarwar Beg and Md Saquib Hasnain, Pharmaceutical Quality by design: Principles and application, Academic press, March 2019.
4. Ron S. Kenett, Shelemyahu Zacks, Daniele Amberti, Modern Industrial Statistics: with applications in R, MINITAB and JMP, 2nd Edition, Wiley, January 2014.
5. N Politis S, Colombo P, Colombo G, M Rekkas D. Design of experiments (DoE) in pharmaceutical development, Drug Dev Ind Pharm. 2017 Jun;43(6):889-901. doi: 10.1080/03639045.2017.1291672.
6. Andrew Teasdale, David Elder, Raymond W. Nims, ICH quality guidelines- An implementation guide, Dec 2017.
7. Gajendra Singh, Gaurav Agarwal an Vipul Gupta, Drug regulatory affairs, CBS publication, 2005.
8. Marc P. Mathieu, New Drug Development: A regulatory overview, Nov 2000.
9. ICH guidelines available in the official website "<https://www.ich.org>".

Course Outcomes: Understand that the areas that come under the Good Laboratory Practices are: personnel and organizational, testing facilities, equipment, testing and controls, records, reports, and protocol for and conduct of non-clinical labs., Understand that the areas that come under GMP are: facilities and buildings, equipment, production, process control, packaging and labeling, laboratory controls, and returned/salvaged drug products., Importance of GMP and GLP for drug regulation.

Course Code	:	PEXXX
Course Title	:	Professional Elective - I
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	PE
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Refer Appendix I for details regarding Professional Elective – I.

Course Code	:	OSXXX
Course Title	:	Open Subject - I
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Refer Appendix II for details regarding Open Subject – I.

Course Code	:	AU301
Course Title	:	Indian Constitution
Number of Credits	:	0 (L: 2 [^] , T: 0, P: 0)
Course Category	:	AU
Continuous Assessment (C.A.)	:	--
End Semester Assessment (E.S.A.)	:	--

Course Content

Unit 1: The Constitution - Introduction

- The History of the Making of the Indian Constitution
- Preamble and the Basic Structure, and its interpretation
- Fundamental Rights and Duties and their interpretation
- State Policy Principles

Unit 2 – Union Government

- Structure of the Indian Union
- President – Role and Power
- Prime Minister and Council of Ministers
- Lok Sabha and Rajya Sabha

Unit 3 – State Government

- Governor – Role and Power
- Chief Minister and Council of Ministers
- State Secretariat

Unit 4 – Local Administration

- District Administration
- Municipal Corporation
- Zila Panchayat

Unit 5 – Election Commission

- a. Role and Functioning
- b. Chief Election Commissioner
- c. State Election Commission

Suggested Learning Resources:

S. No.	Title of Book	Author	Publication
1	Ethics and Politics of the Indian Constitution	Rajeev Bhargava	Oxford University Press, New Delhi, 2008
2	The Constitution of India	B.L. Fadia	Sahitya Bhawan; New edition (2017)

3	Introduction to the Constitution of India	DD Basu	Lexis Nexis; Twenty-Third 2018 edition
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Suggested Software/Learning Websites:

1. <https://www.constitution.org/cons/india/const.html>
2. <http://www.legislative.gov.in/constitution-of-india>
3. <https://www.sci.gov.in/constitution>
4. <https://www.toppr.com/guides/civics/the-indian-constitution/the-constitution-of-india/>

Course Code	:	PS301
Course Title	:	Summer Internship - I
Number of Credits	:	2 (L: 0, T: 0, P: 4)
Course Category	:	PS
Continuous Assessment (C.A.)	:	100
End Semester Assessment (E.S.A.)	:	---

Objective: Minimum of six weeks in an Industry preferably in the area of Biotechnology. The summer internship should give exposure to the practical aspects of the discipline. In addition, the student may also work on a specified task or project which may be assigned to him/her. The outcome of the internship should be presented in the form of a report. This course is aimed to provide more weightage for project work. The project work could be done in the form of a summer project or internship in the industry or even a minor practical project in the college. Participation in any technical event/ competition to fabricate and demonstrate an innovative machine or product could be encouraged under this course.

AICTE Internship Policy available on AICTE's website may be referred for more information regarding Internship.

Guidance/Remarks:

Note: *Internship needs to be done in Summer Break after Semester - IV and will be considered for evaluation in Semester - V.*

SEMESTER VI

Semester VI

Course Code	:	PC302
Course Title	:	Bioseparation Engineering
Number of Credits	:	3 (L: 2, T: 0, P: 2)
Course Category	:	PC
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): It is intended to impart basic undergraduate level knowledge in the area of separation technologies for the biomolecules. Students would be able to understand workflow for the separation of DNA, RNA, proteins, secondary metabolites etc. They would also be able to assimilate recent research findings, advancement and development in the relevant subject.

Course Content: Introduction to separation of biomolecules and its importance in Biotechnology, Working principles of centrifugation, centrifugation-based methods for separation of the cell organelles and biomolecules (DNA, RNA, Proteins and secondary metabolites), Separation of different types of DNA from cells, Separation of the different types of RNA from biological samples, Basics of chromatography and its use in separation of biomolecules, TLC, HPLC, GC etc., Methods for separation of the proteins based on size, charge and chemical nature of the proteins, Isolation and separation of biolipids, Membrane and Rotating Membrane in Bioseparation, TCL for separation of the lipids, Ultrafiltration methods and separation of biomolecules, Polymer beads for immobilization of biomolecules, Magnetic Beads for Bio-separation, Cell Sorting, Microfluidics based separation.

Practicals:

1. Isolation of the plant cell organelles using centrifugation methods.
2. Isolation and separation of the DNA, RNA and proteins using centrifugation and biochemical methods.
3. Separation of the proteins with suitable chromatography methods.
4. Apply filtration and ultrafiltration method for separation of proteins.
5. Use TLC for separation of the biolipids.
6. Isolation of the photosynthetic pigments using centrifugation methods.

Text Books/References:

1. Molecular Cloning - Sambrook Russel - Vol. 1, 2, 3.
2. Fat Detection: Taste, Texture, and Post Ingestive Effects. Montmayeur JP, le Coutre J, editors. Boca Raton (FL): CRC Press/Taylor & Francis; 2010.
3. Biochemistry. 5th edition. Berg JM, Tymoczko JL, StryerL. New York: W H Freeman; 2002.

Course Outcomes: The students will learn how to separate and purify to homogeneity molecules and biological macromolecules of interest using different technologies. The course will also introduce how to scale up the separation in a cost effective manner.

Course Code	:	PC304
Course Title	:	Synthetic & Systems Biology
Number of Credits	:	4 (L: 3, T: 0, P: 2)
Course Category	:	PC
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): This course introduces students to the rapidly evolving field of Systems & synthetic biology. Successful examples illustrating tremendous application potentials of synthetic biology in the fields of biofuels, biomedicine, and other areas will also be discussed. Emphasis has also been laid on the use of online bio-design software and computer labs to design new circuits and assemblies followed by experiments to evaluate their functionality.

Course Content:

Module 1: Introduction to Synthetic biology & Systems biology

Introduction to synthetic biology. Background of Gene Regulatory Mechanisms (Gene Parts- Gene Structure, Promoters, Terminators, Enhancers, Inducers, Repressors, Transcription Factors, Co-factors, transcriptional and post-transcriptional regulation, post-translational modifications). Genetic Engineering and Genome Editing
Various Omics & role in systems biology - genomics, proteomics, transcriptomics, metabolomics

Module 2: Elements of synthetic biology - Tools, circuits, BioBricks

Gene shuffling for large scale pathway assembly and engineering; Choices for microbial hosts for industrial applications- bacteria, yeast, insect. Gene editing methods - CRISPR/Cas; Gene sequencing - Pyrosequencing, Nanopore sequencing. Bacterial circuits: feedback, feed-forward, toggle switch, signal propagators and band filter, synchronized oscillators. Introduction to Bio Bricks & its applications.
Microarrays & systems biology - a basic introduction

Module 3: Mathematical modelling & simulation

Noise in Gene Expression. Mathematical Modeling and Simulation. Biosensors. Application of software tools for modelling gene expression.
Various markup languages used in systems biology. Introduction to various metabolic pathway databases.

Module 4: Commercial Applications

Biomedicine, Biomaterials, Biofuels and Bioremediation; Production of artemisinin as case study. Building the new bio-economy. Introduction to Biofoundries & circuits. Role of automation and robotics in biofactories; Green chemistry - use of plants for engineering biologics & small molecules. Biosurfactants as an example of microbial cell factory based production. Global events & competitions- iGEM, synbiobeta.

Module 5: Regulations & ethics

Safety & bioethics, legal & IP elements involved in synthetic biology applications for human, animals and plants.

Practicals:

1. Introduction to various bio-design software.
2. Design and construction of a biosensor.
3. Gene circuit design and engineering.
4. Crispr-Cas9 based genome editing.

Text Books/References:

1. Uri Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits, Chapman & Hall/CRC (2006).
2. Eric Davidson, The Regulatory Genome: Gene Regulatory Networks In Development And Evolution, Academic Press (2006).
3. Hamid Bolouri, Computational Modeling of Gene Regulatory Networks - A Primer, Imperial College Press (1st edition) (2008).
4. Freemont, P.S and Kitney, R.I. (2012). Synthetic Biology – a Primer. World Scientific Publishing Co pte Ltd
5. Singh, V and P.K. Dhar. (2015). Systems and Synthetic Biology. Springer publishing, Netherlands
6. Fu, P and Panke, S (2009). Systems Biology and Synthetic Biology. Wiley Publishing.
7. Covert, M.W. (2014). Fundamentals of Systems Biology: from Synthetic Circuits to Whole Cell Models. CRC Press
8. Konopka, A. K. (2006). Systems Biology: Principles, Methods, and Concepts. CRC Press.
9. Church, G and Regis, E. (2012). Regenesi: How Synthetic Biology will Reinvent Nature and Ourselves. Basic Books.
10. Standards for Plant Synthetic Biology - <http://onlinelibrary.wiley.com/doi/10.1111/nph.13532/full>
11. Synthetic and Systems Biology for Microbial production of Commodity Chemicals -
12. <http://www.nature.com/articles/npjsba20169>.
13. Biotechnology and Synthetic Biology Approaches for Metabolic Engineering of Bioenergy Crops - <https://www.ncbi.nlm.nih.gov/pubmed/27030440>.
14. Microarray Data Analysis: Gene Expression Data Analysis. A Beginner's Guide by: Helen Causton (Imperial College), J Quackenbush and AlvisBrazma (The European Bioinformatics Institute).
15. A Practical Approach to Microarray Data Analysis (Hardcover) by Daniel P. Berrar (Editor), Werner Dubitzky (Editor), Martin Granzow (Editor).

Course Outcomes: The students will learn the concept of synthetic biology and its widespread applications in research and industry. They will be able to assemble DNA and genes into biological circuits to make a biosensor or even engineer organisms. The students will also appreciate that biological systems are highly dynamic and not static and can be manipulated by various design strategies.

Course Code	:	PC306
Course Title	:	Animal & Plant Biotechnology
Number of Credits	:	4 (L: 2, T: 0, P: 4)
Course Category	:	PC
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s):

1. At the end of this course the students will learn and systematically analyze the complexities defining regulation of various metabolic pathways. They will be able to design and learn strain-engineering strategies to alter cellular behavior, metabolic flux, and product formation. They will also appreciate the vast industrial applications of metabolic engineering in the field of medicine, energy and environment.
2. The course intends to teach students about the traditional and new approaches used in crop improvement. This includes the conventional and marker assisted breeding approaches, plant tissue culture and its importance in generation of transgenic plants, methods to express large quantities of important proteins and modern tools for site directed mutagenesis in plants.

Course Content:

1. **Animal Cell Culture:** History of Animal Cell Culture, Characteristics of animal cell, metabolism, regulation and nutritional requirements, Culture Media and Growth Conditions, Development of Primary Culture and Cell Lines, Suspension Culture, Characterization and maintenance of cell lines, Cryopreservation, Common Cell Culture Contaminants, Marker Gene Characterization, Transfection and Transformation of Cells.
2. **Growth and Scale Up:** Need for scaling-up of cells for vaccine or antigen or pharmaceutical protein production, Hybridoma Technology, Cell culture reactors, Scale-Up in suspension and monolayer cultures, Factors affecting cell growth, Growth Monitoring, Mass Transfer.
3. **Animal Biotechnology:** Concept of transgenic animals, Methods of transgene delivery, Microinjection of recombinant DNA into fertilized eggs/stem cells, Animal Pharming, Organ Culture, Regenerative Medicine, Human Embryonic Stem Cell research, Ethical Concerns and Biosafety.
4. **Crop Improvement:** The need of crop improvement. Conventional methods of crop improvement, selection, mutation, polyploidy and clonal selection. Green revolution in India. Introduction to marker assisted breeding and selection.
5. **Plant tissue culture:** History of plant tissue culture, plasticity and totipotency. Laboratory setup for a typical plant tissue culture facility. Sterilization methods used in plant tissue culture. Types of nutrient media and plant growth regulators in plant regeneration. Pathways for *in vitro* regeneration: organogenesis, somatic and gametic

embryogenesis; protoplast isolation, culture and regeneration; culture of other explants, somatic hybridization; Haploid and triploid production and their applications. Genetic fidelity of plants raised through tissue culture. Applications of micro-propagation, meristem culture, embryo rescue, somaclonal and androclonal variations. Application of tissue culture for crop improvement. Methods for Plant Conservation, Cryopreservation, synseed production. Production of bio active secondary metabolites by plant tissue culture.

6. **Principles and methods of genetic transformation:** Introduction to *Agrobacterium* biology and biotechnology. Mechanism of T-DNA transfer to plants and Agro infection. *A. rhizogenes* and its application. Transplastomics and its utility. Methods for direct gene transfer, Marker and reporter genes; Promoters used in plant vectors. Plant viral vectors. Molecular techniques for analysis of transgenics (copy number, transgene stability, silencing; segregation). Marker-free transgenics and environmental, social and legal issues associated with transgenic plants. Case studies for genetic engineering in plants for traits of agronomic value, biotic, abiotic stresses and herbicide tolerance.
7. **Molecular Farming:** Transgenic crops for production of antibodies, viral antigens and peptide hormones in plants, Edible vaccines and Nutraceuticals. Plant Biotechnology for biofuels.
8. **Genome Editing:** The history of targeted mutations in plants. Use of ZFNs and TALENs as early tools for genome editing. Discovery of CRISPR-Cas system and its applications. Recent innovations in the technology and case studies where CRISPR-Cas has been used for plant improvement.

Practicals:

1. Animal Cell Culture Biosafety and Ethical Concerns
2. Preparation of reagents and media for cell culture
3. Cell counting and plating
4. Maintenance of Adherent (Monolayer) and Suspension Cell culture
5. Cryopreservation of cell lines
6. Determination of common cell culture contaminants
7. Cell Viability Assay (MTT reagent)
8. Cell Cytotoxicity Assay (Trypan Blue Assay)
9. Transfection in mammalian Cell Lines
10. Preparation and sterilization of standard tissue culture media.
11. Sterilization of explants and generation of undifferentiated mass of cells. Regeneration of plants from undifferentiated cells.
12. Preparation of competent cells, transformation and colony PCR for confirmation of transformation in *Agrobacterium tumefaciens*.
13. *Agrobacterium* mediated transformation of plants.
14. Selection and screening of transgenic plants.
15. Evaluation of a transgenic phenotype (viz., Herbicide resistance) under contained conditions.
16. Analysis of crude extracts from medicinal plants using HPLC.
17. Use of microsatellite markers for DNA fingerprinting.

Text Books/References:

1. Culture of Animal Cells by R.I. Freshney.
2. Animal Cell Biotechnology 2007, Humana Press by Portner R.
3. Basic Cell Culture Second Edition, Oxford University Press by Davis, J.M.
4. Principles of Plant Genetics and Breeding by George Acquaah 2007. Blackwell Publishing.
5. An introduction to Plant Tissue culture by MK Razdan. M.K. 2003. Oxford & IBH Publishing Co, New Delhi, 2003.
6. Plant Biotechnology: An Introduction to Genetic Engineering by Adrian Slater, Nigel W. Scott, Mark R. Fowler. Oxford University Press, 2008.
7. Biochemistry & Molecular Biology of Plants. Bob Buchanan, Wilhelm Gruissem, Russell Jones. John Wiley & Sons, 2002.

Course Outcomes: At the end of the course the students will learn the techniques of animal cell culture, its scale up strategies and its application to human disease and welfare. They will also be sensitized to the ethical concerns associated with the development of transgenic, animal cloning and pharming and stem cell research. Further, they will learn about biotechnological application of plants.

Course Code	:	PEXXX
Course Title	:	Professional Elective – II
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	PE
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Kindly Refer Appendix I on Professional Electives.

Course Code	:	OSXXX
Course Title	:	Open Subject – II
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Kindly Refer Appendix II on Open Subjects.

SEMESTER VII

Semester VII

Course Code	:	HS401
Course Title	:	Intellectual Property Rights (IPR) & Regulatory
Number of Credits	:	2 (L: 1, T: 1, P: 0)
Course Category	:	HS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s):

- To disseminate knowledge on patents, patent regime in India and abroad and registration aspects
- To make students aware about current trends in IPR and Govt. supports in promoting IPR
- To classify the role of regulatory committees in controlling the risk

Course Content:

Unit I: Intellectual Property Rights: Introduction and the need for intellectual property right (IPR) - Kinds of Intellectual Property Rights: Patent, Copyright, Trade Mark, Design, Geographical Indication, Plant Varieties and Layout Design – Genetic Resources and Traditional Knowledge – Trade Secret - IPR in India : Genesis and development – IPR in abroad - Major International Instruments concerning Intellectual Property Rights: Paris Convention, 1883, the Berne Convention, 1886, the Universal Copyright Convention, 1952, the WIPO Convention, 1967, the Patent Co-operation Treaty, 1970, the TRIPS Agreement, 1994 India's New National IP Policy, 2016 – Govt. of India step towards promoting IPR – Govt. Schemes in IPR – Career Opportunities in IP - IPR in current scenario with case studies.

Unit II: Biosafety-Regulatory Framework for GMOs in India & at International

Level: Regulatory framework in India governing GMOs-Recombinant DNA Advisory Committee (RDAC), Institutional Biosafety Committee (IBSC), Review Committee on Genetic Manipulation, Genetic Engineering Approval Committee (GEAC), Recombinant DNA Guidelines (1990), Revised Guidelines for Research in Transgenic Plants (1998), Seed Policy (2002), Prevention Food Adulteration Act (1955), The Food Safety and Standards Bill (2005), Plant Quarantine Order (2003), Regulation for Import of GM Products Under Foreign Trade Policy (2006-2007), National Environment Policy (2006). Rules for the manufacture, use/import/export and storage of hazardous microorganisms/genetically engineered organisms or cells (Ministry of Environment and Forests Notification, (1989).

Convention of Biological Diversity (1992) – Cartagena Protocol on Biosafety – Objectives and salient features of Cartagena Protocol.

Understand the legal steps involved in progressing a new drug to market. Grasping the current regulatory acts and safety norms of the modern pharmaceutical industries

Unit III: Bioethics: Patenting live microorganism, Human Genome project and ethical issues, Animal cloning, human cloning and their ethical issues, Experimenting on animals.

Public education of producing transgenic organism, legal and socioeconomic impacts of biotechnology, testing drugs on human volunteers, Hazardous materials used in biotechnology, their handling and disposal.

Text Books/References:

1. Nithyananda, K V. (2019). Intellectual Property Rights: Protection and Management. India, IN: Cengage Learning India Private Limited.
2. Neeraj, P., & Khusdeep, D. (2014). Intellectual Property Rights. India, IN: PHI learning Private Limited.
3. V Sreekrishna, 2017. Bioethics and Biosafety in Biotechnology by New Age International publishers.

E-resources:

1. Subramanian, N., & Sundararaman, M. (2018). Intellectual Property Rights – An Overview. Retrieved from <http://www.bdu.ac.in/cells/ipr/docs/ipr-eng-ebook.pdf>
2. World Intellectual Property Organization. (2004). WIPO Intellectual Property Handbook. (https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub_489.pdf)

Course Outcomes:

- The students shall get an adequate knowledge on patent and copyright. This provide further way for developing their idea or innovations.
- Identify the role of regulatory committees in controlling the risk.
- Students should get enough information on ethical issues linked to research on animal models, transgenics, clinical trials.
- Students to consider Intellectual Property (IP) as a career option as IP Counsel/Patent Examiner/Patent agent.

Course Code	:	PC401
Course Title	:	Data Analysis and Simulations
Number of Credits	:	3 (L: 2, T: 0, P: 2)
Course Category	:	PC
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective: In this course, the students will learn the principles and methods of statistical analysis, but will also put them into practice using a range of real-world data sets. The objective of the course is to provide a basic understanding of data analysis using statistics and to use computational tools on problems of applied nature. Applications of data science techniques such as machine learning, deep learning and their applications in biological data.

Course Content:

Data preprocessing and visualization: Types of data, dealing with missing data, data visualization: Scatter Plot, histogram, group plots, box plots etc., dimensionality reduction.

Data analysis: Statistical analysis, hypothesis testing, significance of p-value, chi-square, T-test, ANOVA, Bayesian Probability.

Mining Frequent Patterns: Associations and Correlations, Classification.

Machine learning: Supervised, unsupervised, logistic regression, SVMs, decision trees, clustering and model evaluation.

Artificial neural networks: Types of ANN, case studies for the application of deep learning in biology and health care research.

Practicals:

1. Plotting graphs using MS Excel.
2. Statistical data analysis using PSPP.
3. Implementing machine learning algorithms.
4. Deep learning using Deep Learning Studio Desktop.

Text Books/References:

1. Introduction to Machine Learning using Python, Jeeva Jose, Khanna Publishing House, 2019.
2. Data Mining: Concepts and Techniques by Jiawei Han, Jian Pei, Micheline Kamber, Elsevier; Third edition 2007.
3. Deep Learning by Ian Goodfellow, Yoshua Bengio, MIT Press 2017.
4. Data Visualization – A Practical Introduction by Kieran Healy, Princeton University Press 2019.
5. Deep Learning – Rajiv Chopra, Khanna Publishing House, 2019.

Course Outcomes: On completion of this course, students will be able to gain insights such as correlation and basic analysis using data visualization. Students can present their research results in probabilistic terms using statistical significance. Students can build and train machine learning models and evaluate them; get accustomed with deep learning techniques and their applications in biological and healthcare data.

Course Code	:	PEXXX
Course Title	:	Professional Elective – III
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	PE
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Kindly Refer Appendix I on Professional Electives.

Course Code	:	PEXXX
Course Title	:	Professional Elective – IV
Number of Credits	:	3 (L: 2, T: 1, P: 0)
Course Category	:	PE
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Kindly Refer Appendix I on Professional Electives.

Course Code	:	OSXXX
Course Title	:	Open Subject – III
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Kindly Refer Appendix II on Open Subjects.

Course Code	:	OSXXX
Course Title	:	Open Subject – IV
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Kindly Refer Appendix II on Open Subjects.

Course Code	:	PS401
Course Title	:	Project-I
Number of Credits	:	2 (L: 0, T: 0, P: 4)
Course Category	:	PS
Continuous Assessment (C.A.)	:	100
End Semester Assessment (E.S.A.)	:	---

Objective: To synthesize and apply the knowledge gained over the engineering programme to solve real world problems.

Guidance/Remarks: Project-I can be done either during the Summer Break between Semester VI and Semester VII or during the Semester VII. It will be evaluated as part of Semester VII. It may either be a complete project related to the field of Biotechnology or it may be an initiation (Phase I) of Project-II present in Semester VIII, provided the “Project Work II” is expected to extend beyond the duration of 6 months.

Course Code	:	PS403
Course Title	:	Summer Internship – II
Number of Credits	:	3 (L: 0, T: 0, P: 6)
Course Category	:	PS
Continuous Assessment (C.A.)	:	100
End Semester Assessment (E.S.A.)	:	---

Objective: Minimum of six weeks in an Industry preferably in the area of Biotechnology. The summer internship should give exposure to the practical aspects of the discipline. In addition, the student may also work on a specified task or project which may be assigned to him/her. The outcome of the internship should be presented in the form of a report. This course is aimed to provide more weightage for project work. The project work could be done in the form of a summer project or internship in the industry or even a minor practical project in the college. Participation in any technical event/ competition to fabricate and demonstrate an innovative machine or product could be encouraged under this course.

AICTE Internship Policy available on AICTE’s website may be referred for more information regarding Internship.

Remarks: Internship needs to be done in Summer Break after Semester - VI and will be considered for evaluation in Semester - VII.

SEMESTER VIII

Semester VIII

Course Code	:	PS402
Course Title	:	Project-II (Biotech Industrial or Biotech In-house Project or Bio-Entrepreneurship)
Number of Credits	:	9 (L: 0, T: 0, P: 18)
Course Category	:	PS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Objective: To synthesize and apply the knowledge gained over the engineering programme to solve real world problems.

Guidance/Remarks: Project-II has to be done during Semester VIII. It may be initiated in the break between Semester VII & VIII although it is not mandatory to initiate in the break. It will be evaluated as part of Semester VIII. It may either be a complete project related to the field of Biotechnology or it may be an extension (Phase II) of Project-I present in Semester VII, provided the Project in charge agrees that "Project Work I" is worthy enough to extend across two semesters (i.e. VII & VIII). It may also be a startup in the field related to Biotechnology. In the case of startups, substantial evidence has to be produced for evaluation of the work carried out as part of Project-II.

APPENDIX – I

Appendix – I: Professional Electives

List of available courses under Professional Elective – I (L: 3; T:1; P:2; C:5)	
S. No.	Course Title
1	Big Data Analytics
2	Genome Editing
3	Biosimilars Technology

List of available courses under Professional Elective – II (L: 3; T:1; P:2; C:5)	
S. No.	Course Title
1	Machine Learning
2	Waste Management & Upcycling
3	Stem-Cell Technology

List of available courses under Professional Elective – III (L: 3; T:1; P:2; C:5)	
S. No.	Course Title
1	Gene Expression and Transgenics
2	Rational Drug Discovery
3	State-of-the-art Imaging

List of available courses under Professional Elective – IV (L: 2; T:1; P:0; C:3)	
S. No.	Course Title
1	Precision Medicine & Wellness
2	Tissue Engineering
3	Nano Biotechnology

Suggestive guideline for selection of professional electives:

Suggestive Order 1: Big Data Analytics, Machine Learning, Rational Drug Discovery, Nano Technology.

Suggestive Order 2: Genome Editing, Stem-Cell technology, Gene Expression and Transgenics, Precision Medicine & Wellness.

Suggestive Order 3: Biosimilars Technology, Waste Management & Upcycling, Stat-of-the-art Imaging, Nano-Biotechnology.

➤ **Professional Elective – I**

Course Code	:	PE301
Course Title	:	Big Data Analytics
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	PE
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Note: This is a suggestive subject which is supposed to be helpful to Biotechnology Students. However, the syllabus for this may be designed by the appropriate body of the University OR they may float just PE303 (Genome Editing) and PE305 (Biosimilars Technology) as part of “Professional Elective I”.

Course Code	:	PE303
Course Title	:	Genome Editing
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	PE
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The course will provide the technical details and applications of modern tools for precision gene targeting and editing. The course will also provide information about targeted gene silencing.

Course Content: Overview of traditional methods: homologues recombination for gene knockout. RNAi system, Cre-LoxP and Flp-FRT systems. Engineered enzyme systems: Zinc finger nucleases (ZFNs), transcription-activator like effector nucleases (TALEN), meganucleases and the clustered regularly interspaced short palindromic repeats (CRISPR/Cas9) system. Design of sgRNA. Multiplex Automated Genomic Engineering (MAGE). Applications in Targeted gene mutation, Gene therapy, creating chromosome rearrangement, Study gene function with stem cells, Transgenic animals, Endogenous gene labeling, targeted transgene addition, GM plants, application is biofuel production and in bioremediation. Ethics, safety and risk of targeted gene editing.

Text Books/References:

1. CRISPR Gene Editing, Methods and Protocols, Editors: Luo, Yonglun (Ed.)
2. Genome Editing and Engineering, From TALENs, ZFNs and CRISPRs to Molecular Surgery. Edited by Krishnarao Appasani.
3. Progress in Molecular Biology and Translational Science Vol 149-Genome Editing in Plants. Edited by Donald P. Weeks and Bing Yang. Academic Press.
4. Precision Medicine, CRISPR, and Genome Engineering, Moving from Association to Biology and Therapeutics, Editors: Tsang, Stephen H. (Ed.). Springer.

Course Outcomes: At the end of this course, the students will learn and systematically analyze technical details of precise gene-editing tools. They will also appreciate the vast applications of gene editing in the field of medicine, agriculture, and the environment. They will also learn the risk, safety, and ethics of gene editing tools.

Course Code	:	PE305
Course Title	:	Biosimilars Technology
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	PE
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective: To introduce students about the design and development of different kinds of biologics, biomimetics, and biosimilars. Students will learn about their different biotechnological applications. Further, the course will introduce the regulatory framework about the Biosimilars.

Course Content:

Module 1: Introduction to Biopharma

Generics in Biopharma, definition of biologics, biosimilars, super biologics, differences between chemical genetics and biosimilars, The developmental and regulatory challenges in biosimilar development, Prerequisites for Biosimilar development, Biosimilar market potential.

Module 2: Types of biosimilar drugs

Peptides, proteins, antibodies, Enzymes, Vaccines, Nucleic acid based therapies (DNA, RNA, etc), Cell based therapies (including stem cells)

Module 3: Characterization methods

Aggregation- precipitation, floccule strength, precipitate ageing & kinetics, adsorption of proteins & peptides on surfaces, effect of temperature on protein structure, hydration & thermal stability of proteins - solid powders, suspension on non-aqueous solvents, reversed micelles, aqueous solution of polyols, analytical and spectrophotometric characterization of proteins, protein sequencing and structure determination

Module 4: Bioequivalence studies

Immunogenicity & allergenicity of biosimilars; factors affecting immunogenicity - structural, post-translational modifications, formulations, impurities, manufacturing and formulation methods for biosimilars; types of bioequivalence (average, population, individual), experimental designs & statistical considerations for bioequivalence studies (Non-replicated designs – General Linear Model, Replicated crossover designs), introduction to “ORANGE BOOK” & “PURPLE BOOK”.

Module 5: Case studies

Indian companies working in this space & their product pipeline (Biocon, Intas, Dr Reddy's, Reliance, Bharat Biotech, Lupin, Cipla, Shanta, etc); products - Erythropoietin, growth hormone, granulocyte stimulating factors, interferons, streptokinase, monoclonal antibodies.

Practicals:

List of 25 FDA approved biosimilars in the global pharma market - their reference product & biosimilar equivalents.

Text Books/References:

1. Laszlo Endrenyi, Paul Declerck and Shein-Chung Chow, Biosimilar Drug Development, Drugs and Pharmaceutical Sciences, Vol 216, CRC Press.
2. Cheng Liu and K. John Morrow Jr., Biosimilars of Monoclonal Antibodies: A Practical Guide to Manufacturing, Preclinical and Clinical Development, Wiley, Dec 2016.
3. <https://www.drugs.com/medical-answers/many-biosimilars-approved-united-states-3463281/>

Course Outcomes: The course gives the student a perspective of the complexity to establish biosimilarity of therapeutic proteins and biologics.

➤ **Professional Elective - II**

Course Code	:	PE302
Course Title	:	Machine Learning
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	PE
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s):

1. To introduce students to the basic concepts and techniques of Machine Learning.
2. To have a thorough understanding of the Supervised and Unsupervised learning techniques.
3. To study the various probability based learning techniques.
4. To understand graphical models of machine learning algorithms.

Course Content:

UNIT I: Introduction

Learning – Types of Machine Learning – Supervised Learning – The Brain and the Neuron – Design a Learning System – Perspectives and Issues in Machine Learning – Concept Learning Task – Concept Learning as Search – Finding a Maximally Specific Hypothesis – Version Spaces and the Candidate Elimination Algorithm – Linear Discriminants – Perceptron – Linear Separability – Linear Regression.

UNIT II: Linear Models

Multi-layer Perceptron – Going Forwards – Going Backwards: Back Propagation Error – Multi-layer Perceptron in Practice – Examples of using the MLP – Overview – Deriving Back-Propagation – Radial Basis Functions and Splines – Concepts – RBF Network – Curse of Dimensionality – Interpolations and Basis Functions – Support Vector Machines.

UNIT III: Tree and Probabilistic Models

Learning with Trees – Decision Trees – Constructing Decision Trees – Classification and Regression Trees – Ensemble Learning – Boosting – Bagging – Different ways to Combine Classifiers – Probability and Learning – Data into Probabilities – Basic Statistics – Gaussian Mixture Models – Nearest Neighbor Methods – Unsupervised Learning – K means Algorithms – Vector Quantization – Self Organizing Feature Map.

UNIT IV: Dimensionality Reduction and Evolutionary Models

Dimensionality Reduction – Linear Discriminant Analysis – Principal Component Analysis – Factor Analysis – Independent Component Analysis – Locally Linear Embedding – Isomap – Least Squares Optimization – Evolutionary Learning – Genetic algorithms – Genetic Offspring: - Genetic Operators – Using Genetic Algorithms – Reinforcement Learning – Overview – Getting Lost Example – Markov Decision Process.

UNIT V: Graphical Models

Markov Chain Monte Carlo Methods – Sampling – Proposal Distribution – Markov Chain Monte Carlo – Graphical Models – Bayesian Networks – Markov Random Fields – Hidden Markov Models – Tracking Methods.

Practicals: Suitable Practicals based on topics covered in theory should be designed and given to students for practice by the Course Instructor.

Text Books:

1. Stephen Marsland, – Machine Learning – An Algorithmic Perspective||, Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.
2. Tom M Mitchell, –Machine Learning||, First Edition, McGraw Hill Education, 2013.
3. Jeeva Jose, - Introduction to Machine Learning using Python||, First Edition, Khanna Publishing House, 2019.

References:

1. Peter Flach, –Machine Learning: The Art and Science of Algorithms that Make Sense of Data||, First Edition, Cambridge University Press, 2012.
2. Jason Bell, –Machine learning – Hands on for Developers and Technical Professionals||, First Edition, Wiley, 2014.
3. Ethem Alpaydin, –Introduction to Machine Learning 3e (Adaptive Computation and Machine Learning Series) ||, Third Edition, MIT Press, 2014.
4. Rajiv Chopra, - Machine Learning ||, Khanna Book Publishing Co. 2019.

Course Outcomes: Upon completion of the course, the students will be able to:

- Distinguish between, supervised, unsupervised and semi-supervised learning
- Apply the apt machine learning strategy for any given problem
- Suggest supervised, unsupervised or semi-supervised learning algorithms for any given problem.

- Design systems that uses the appropriate graph models of machine learning.
- Modify existing machine learning algorithms to improve classification efficiency.

Course Code	:	PE304
Course Title	:	Waste Management & Upcycling
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	PE
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s):

- To introduce fundamental aspects of types of waste and its management.
- To disseminate knowledge on various waste management technologies.
- To provide knowledge on how waste can be converted to wealth in a sustainable way.
- To enable students to think innovative way to develop concepts in waste management.

Course Content:

UNIT I

Waste management: The definition of waste, and its classification in the context of EU legislation, policy and other drivers for change, including the planning and permitting regime for the delivery of waste management solutions

Liquid waste collection, treatment and disposal systems: Segregation and mixing schemes; Pre-treatment and its role in the industrial wastewater management; Overview of wastewater treatment technologies and development of wastewater treatment schemes; Operation and maintenance of effluent treatment plants; and Case study of an industrial wastewater management system.

Air Pollution management and treatment: Overview of industrial emissions; Air pollution control systems and overview of air pollution control technologies; Development of schemes for the collection, treatment and discharge industrial emissions;

UNIT II

Technologies for Waste treatment technologies: waste incineration and energy from waste, pyrolysis and gasification, anaerobic digestion, composting and mechanical biological treatment of wastes, managing biomedical waste.

UNIT III

Health considerations in the context of operation of facilities, handling of materials and impact of outputs on the environment; Advances in waste recycling and recovery technologies to deliver added value products; Landfill engineering and the management of landfill leachate and the mining of old landfills.

UNIT IV

Interface of waste and resource management and civil engineering in the context of sustainable waste management in global cities and developing countries; and Use of

decision support tools including multi-criteria analysis, carbon foot-printing and life-cycle analysis, as appropriate.

UNIT V

Waster Upcycling, waste reuse, Waste down cycling, waste upcycling a social enterprise, Case study in each area. Innovative technologies for sustainable waste management.

Text Books/References:

1. O.P. Gupta, “Elements of Solid & Hazardous Waste Management”, Khanna Publishing House, New Delhi, 2019.
2. George Tchobanoglous et.al., “Integrated Solid Waste Management”, McGraw-Hill Publishers, 1993.
3. B.Bilitewski, G.HardHe, K.Marek, A.Weissbach, and H.Boeddicker, “Waste Management”, Springer, 1994.

Course Outcomes:

- The students shall get an adequate knowledge on waste and its sustainable management.
- Students should get enough knowledge on safety guidelines of waste management.
- Students in groups shall develop concepts in managing waste of their institutions.
- Students should get experiential learning with a waste management company in the vicinity.

Course Code	:	PE306
Course Title	:	Stem-Cell Technology
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	PE
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): To impart knowledge of wide-ranging topics related to stem cells and regenerative biology, including a brief history of the field, research on animal models of regeneration, tissue engineering, social and ethical issues related to stem cell research.

Course Content:

Introduction to Stem Cells: Principles and properties of stem cells, types of stem cells, comparison of embryonic and adult stem cells.

Stem Cell Niche: Introduction to stem cell niches in gut epithelium, bone marrow, epidermis, testis and neural tissues.

Cell Cycle and Development: Cell cycle regulators and checkpoints, cell fusion, differentiation of stem cells and their role in self-renewal.

Epigenetic Control: DNA-methylation and histone modifications, genomic imprinting, telomerase regulation, X-chromosome inactivation, reprogramming of cells, induced

pluripotent stem cells and their therapeutic applications.

Types and Regeneration: Stem cells derived from amniotic fluid, extra embryonic membrane, germ cells, hematopoietic organs, neurons and kidney, cord blood transplantation, donor selection, HLA matching, patient selection, peripheral blood and bone marrow transplantation, bone marrow and cord blood collection procedures and cryopreservation and their applications.

Experimental Methods: Isolation and differentiation of human adult stem cells, embryonic stem cells and mouse stem cells, stem cell techniques: fluorescence activated cell sorting (FACS), time lapse video, green fluorescent protein tagging.

Applications: Stem cells applications in cancer, diabetes, heart disease, muscular dystrophy, regeneration of epidermis; stem cell regulations, debate, social and ethical concerns, Organ farming.

Practicals

1. Colony formation assays
2. Culture of adult stem cells
3. Real Time PCR for stem cell markers
4. Western blot for stem cell markers
5. Adult stem cell differentiation and visualization by staining (Example: Adipocytes)

Text Books/References:

1. Hematopoietic Stem Cell Transplantation by Treleaven, J., first edition 2009.
2. Essentials of Stem Cell Biology by Lanza, R., second Edition, 2009 Academic Press.
3. Molecular Cell Biology by Lodish et al., sixth Ed., W.H. Freeman & Co. 2008.
4. Stem Cells: From Bench to Bedside by Bongso and Ariff.

Course Outcomes: The students will learn isolation, characterization, and applications of stem cells in Biotechnology.

➤ **Professional Elective - III**

Course Code	:	PE401
Course Title	:	Gene Expression and Transgenics
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	PE
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The course will provide the technical details and use of different gene expression systems for overexpression of recombinant proteins and protein complexes for different applications. The course will also provide details about the

purification of proteins expressed in different expression systems. The course will teach about the generation of transgenic animals for research.

Course Content: Overview of recombinant protein expression vectors and promoters: Vectors with tags His, GST, MBP, GFP. Cleavable tag and non-cleavable tags. Vectors for tag free protein expressions. Over-expression of integral membrane proteins. Over-expression in *E. coli*, *B. subtilis*, *Corynebacterium*, *Pseudomonas fluorescens*, yeasts like *S. cerevisiae* and *Pichia pastoris*, insect cell lines like Sf21, Sf9 and BTI-TN-5B1-4, Mammalian cell line like Chinese Hamster ovary (CHO) and Human embryonic kidney (HEK), Plant single cell. Chloroplast transformation and protein expression in chloroplasts. Cell free protein Expression-Cell free extracts from *E. coli*, rabbit, wheat germ, insects. Purification of tagged and tag-free proteins. GMP and GLP requirements. Use of transgenic animals. History, safety and ethics of transgenic animals. Methods for creation of transgenic animals-DNA microinjection, Embryonic stem cell-mediated gene transfer, Retrovirus-mediated gene transfer. Use transgenic animals in medical research, in toxicology, in mammalian developmental genetics, in molecular biology in the pharmaceutical industry, in biotechnology, in aquaculture and in xenografting. Humanised animal models

Text Books/References:

1. Gene Expression Systems, Using Nature for the Art of Expression. Edited by Joseph M. Fernandez and James P. Hoeffler.
2. Regulation of Gene Expression, By Perdew, Gary H., Vanden Heuvel, Jack P., Peters, Jeffrey M. Springer.
3. Prokaryotic Gene Expression. Edited by Simon Baumberg. Oxford Press
4. Transgenic Animal Technology, 3rd Edition, A Laboratory Handbook by Carl Pinkert. Elsevier.
5. Ethical Use of Transgenic Animals (English, Paperback, Shah Krunal V). Lambert
6. Transgenic Animals as Model Systems for Human Diseases. Edited E. F. Wagner F. Theuring. Springer.

Course Outcomes: At the end of this course the students will know protein expression in different heterologous host systems and application. The students will learn the methods for creation of transgenic animals and their use in biotechnology research.

Course Code	:	PE403
Course Title	:	Rational Drug Discovery
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	PE
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): This course is aimed at imparting knowledge and skill to understand the drug discovery process, rational methods to identify and design

molecules for new medications greatly shortening the discovery phase of drug development by computational methods.

Course Content:

Unit-I Molecular Modelling in Drug Discovery:

Drug discovery process, Role of Bioinformatics in drug design, Methods of computer aided drug design, ligand design methods, drug design approaches, Target identification and validation, lead optimization and validation, Structure and ligand based drug design, modelling of target-small molecule interactions, Molecular simulations. Protein Modelling.

Unit-II Quantum Mechanics and Molecular Mechanics:

Features of molecular mechanics force fields; Bond structure and bending angles – electrostatic, van der Waals and non – bonded interactions, hydrogen bonding in molecular mechanics; Derivatives of molecular mechanics energy function; Application of energy minimization.

Unit-III Molecular Dynamics simulation methods:

Molecular Dynamics using simple models; Molecular Dynamics with continuous potentials and at constant temperature and pressure; Time – dependent properties; Solvent effects in Molecular Dynamics; Conformational changes from Molecular Dynamics simulation and application.

Unit-IV Molecular Docking and lead optimization:

Molecular Docking; Types of Molecular Docking, docking algorithms and programs, Structure-based methods to identify lead compounds; de novo ligand design; Applications of 3D Databases Searching and virtual Screening; Strategy for target identification and Validation, lead identification, optimization and validation. Combinatorial chemistry and library design, virtual screening, drug likeness and compound filtering, Absorption, distribution, metabolism, excretion and toxicity (ADMET) property prediction, computer based tools for drug design.

Unit-V Pharmacophore and QSAR:

Pharmacophore derivation, 3D pharmacophore prediction and application in drug discovery; QSARs and QSPRs, QSAR Methodology, Various Descriptors used in QSARs: Electronic; Topology; Quantum Chemical based Descriptors. Use of Genetic Algorithms, Neural Networks and Principal Components Analysis in the QSAR equations.

Laboratory: Rational Drug Discovery

1. Role of Bioinformatics in drug design
2. Structure Based Drug Design
3. Coordinate System
4. Quantum Mechanics
5. Energy concept and its importance in drug action
6. Pharmacophore hypothesis
7. ADME calculation
8. Solvent effects in Molecular Dynamics
9. Application of 3D Database searching in Molecular Docking

10. Receptor theories and drug action

Text Books/References:

1. Computational methods in drug design Fred E. Cohen, Walter Hamilton Moos Publisher: ESCOM Science, 1993.
2. Molecular Modelling for Beginners - Alan Hinchliffe Publisher: John Wiley & Sons Inc, 2008. ISBN: 978-0470513149.
3. Combinatorial Library Design and Evaluation: Principles, Software, Tools, Applications in Drug Discovery – Arup Ghose, Vellarkad Viswanadhan Publisher: CRC Press, 2001. ISBN: 0-8247-0487-8.
4. Molecular Modeling Basics - Jan H. Jensen Publisher: CRC Press, 2010. ISBN 978-1420075267.
5. 3D QSAR in Drug Design: Recent Advances – Hugo Kubinyi, Gerd Folkers, Yvonne C. Martin Publisher: Springer Science & Business Media. ISBN: 0-306-46858-1.
6. Computational Chemistry and Molecular Modeling - K. I. Ramachandran, Gopakumar Deepa, Krishnan Namboori Publisher: Springer – Verlag Berlin Heidelberg. ISBN: 978-3540773023.

Course Outcomes: Exposure to various methods of rational drug design such as modelling of protein and target-small molecule interactions, molecular docking, lead optimization, Combinatorial chemistry and library design, Virtual screening, Toxicity (ADMET) property analysis, Pharmacophore and QSAR.

Course Code	:	PE405
Course Title	:	State-of-the-art Imaging
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	PE
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The course will teach the students about technical details and application of modern state-of-the-art imaging techniques. Students will learn about the acquisition of image processing and analysis.

Course Content: Overview and limitations of traditional imaging methods. Confocal microscopy, Super-resolution microscopy- Deterministic functional techniques- Stimulated emission depletion (STED), Ground state depletion (GSD), Saturated structured illumination microscopy (SSIM). Stochastic optical reconstruction microscopy (STORM), photo activated localization microscopy (PALM) and fluorescence photo-activation localization microscopy (FPALM), Points accumulation for imaging in nanoscale topography (PAINT), Label-free localization microscopy. Multi-photon imaging systems, Real time imaging, computerized tomography (CT) imaging, Positron Emission Tomography (PET), Magnetic Resonance Imaging (MRI), Functional MRI (fMRI), Tissue imaging through mass spectroscopy. Image recognitions and artificial intelligence.

Text Books/References:

1. Super-Resolution Microscopy: A Practical Guide, By Udo J. Birk. Wiley
2. Super-Resolution Microscopy, Methods and Protocols,, Editors: Erfle, Holger (Ed.). Springer
3. Super-Resolution Imaging in Biomedicine, By Alberto Diaspro, Marc A. M. J. van Zandvoort. CRC Press
4. Multiphoton Microscopy. Editors: Hartveit, Espen (Ed.). Springer
5. Confocal and Two-Photon Microscopy: Foundations, Applications and Advances By Alberto Diaspro (Editor). Academic Press
6. Basics of PET Imaging, Physics, Chemistry, and Regulations, By Saha, Gopal B.
7. MRI and Spectroscopy in Pharma. & Clinical Research by N. R. Jagannathan
8. Magnetic Resonance Imaging: Physical and Biological Principles, By Stewart C. Bushong. Elsevier
9. Imaging Mass Spectrometry, Protocols for Mass Microscopy. Editors: Setou, Mitsutoshi.

Course Outcomes: At the end of this course the students will know about modern state-of-the-art imaging techniques. They learn about the principles and applications.

➤ Professional Elective – IV

Course Code	:	PE407
Course Title	:	Precision Medicine & Wellness
Number of Credits	:	3 (L: 2, T: 1, P: 0)
Course Category	:	PE
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The course will teach the students about use of modern omics techniques and systems biology in providing personalized medicine and preventive health care.

Course Content: Use of genomics, transcriptomics, proteomics and metabolomics in understanding disease condition. Biomarker identification and validation of a disease state. Human Genome project. Cancer genome project. Different types of genetic and non-genetic variations, Genetic screening and diagnosis: prenatal carrier testing and newborn screening for Mendelian diseases, Pharmacogenomic testing for drug selection, dosing and predicting adverse effects of commonly prescribed drugs, Tumor profiling, Patient data and clinical decisions. Risk assessment through omics approach. Ethical, legal, and social implications of health privacy and policy laws for precision medicine. Ayurveda system of *Prakriti* and *Agni*.

Text Books/References:

1. National Institute of General Medical Sciences. The New Genetics. Bethesda, MD: U.S. Department of Health and Human Services.

2. Genomic and Precision Medicine, Geoffrey Ginsburg and Huntington Willard,
3. The Language of Life: DNA and the Revolution in Personalized Medicine, Francis S. Collins.

Course Outcomes: At the end of this course the students will be introduced to precision medicare and preventive care system using modern omics tools. They will be exposed to recent advances in disease risk prediction, molecular diagnosis and progression of diseases, and targeted therapies for individuals.

Course Code	:	PE409
Course Title	:	Tissue Engineering
Number of Credits	:	3 (L: 2, T: 1, P: 0)
Course Category	:	PE
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The course will impart knowledge of biomaterials and their widespread biomedical applications.

Course Content:

Biomaterials: Natural and synthetic polymers.

Basic biology: Fibrous extracellular matrix of the human body and their characteristic features, Cell-Polymer interaction.

Methods to develop Scaffolds for Tissue engineering: hydrogel, porous scaffold, and Textile-based techniques used for medical application, Rapid prototyping/3D printing, Wound healing.

Organ regeneration: Cartilage, Skin, Liver, Blood Vessel, Kidney, Urinary bladder, Tendons, Ligaments, Cornea.

Text Books/References:

1. Principles of Tissue Engineering, 4th Edition, Editors: Robert Lanza, Robert Langer, Joseph Vacanti, eBook ISBN: 9780123983701, Imprint: Academic Press,
2. Tissue Engineering: Principles and Practices, 1st Edition, John P. Fisher, Antonios G. Mikos, Joseph D. Bronzino, Donald R. Peterson, CRC Press, ISBN 9781138077867 - CAT# K34349,
3. Biomaterials for Musculoskeletal Regeneration- Applications By Bikramjit Basu, Sourabh Ghosh, Springer, 2016, ISBN 978-981-10-3017-8.

Course Outcomes: The students will gain knowledge of biomaterials and their widespread biomedical applications.

Course Code	:	PE411
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Course Title	:	Nano Biotechnology
Number of Credits	:	3 (L: 2, T: 1, P: 0)
Course Category	:	PE
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): This course is designed to make students understand the intersection of nanotechnology and biology. It will also acquaint students with Nano devices of biomedical applications. Students will know about the use of nanotechnology in diagnostic biology and learn about the health and environmental impacts of nanotechnology.

Course Content:

Basics of Quantum Mechanics and Atomic Structure: Duality of light, de Broglie waves, electrons in potential well, structure of hydrogen atom, classic atomic bonding, LCAO theory, band theory, energy bands for metals, semi-conductors and insulators

Surface Science of Nanomaterials: crystal structure, close packed structures – FCC, HCP and BCC, surface structure for close-packed surfaces, surface reconfiguration (surface relaxation & surface reconstruction) adsorption, wetting, surface area in nanomaterials

Introduction to Nanostructures: Carbon nanotubes (CNT), fullerene ('C60'), quantum dots and semiconductor nanoparticles, metal-based nanostructures, nanowires, polymer-based nanostructures, gold nanostructures

Nanomaterial Characterization: X-ray diffraction, electron microscopy, interaction between electron beam and solids, TEM, SEM, SPM (STM & AFM), AES, XPS, SIMS

Nano biomaterials: Biomimetic nanotechnology, protein-based nanostructures, Nano motors, bacterial (E. coli) and mammalian (Myosin family), DNA nanotechnology, nanostructures in cells study, microarray platforms, Nano printing of DNA, RNA, and proteins biochips applications in nano scale detection, lab-on-a-chip devices (LOC), tissue engineering

Nanotechnology in Biomedical Application: micro- and Nano electromechanical devices in drug delivery, other applications in drug delivery, photodynamic therapy in targeted drug administration, Nano biosensors, applications of quantum dots in biotechnology, DNA based nanomaterials as biosensors

Health and Environmental Impacts of Nanotechnology: Engineered nanomaterial of relevance to human health, routes of entry into the body, toxic effects on health, plants and microbes are nanofactories

Text Books/References:

1. Fundamentals and applications of nanomaterials by Guo Z and Tan L, Artech house (2009).

2. Nanobiotechnology by Balaji S, MJP Publishers (2010).
3. Nanobiotechnology: concepts, applications and perspectives by Niemeyer CM and Mirkin CA, Wiley-VCH (2004).
4. Introduction to Nanoscience by Lindsay SM, Oxford University Press (2010).

Course Outcomes: Students will know about the use of nanomaterial and nanotechnology in basic biology and biomedical and agro applications. They will also learn how to design and fabricate nanomaterials and nanodevices.

APPENDIX – II

Appendix – II: Open Subjects

List of available courses under Open Subject – I (L: 3; T:1; P:2; C:5)	
S. No.	Course Title
1	3D Printing & Design
2	Internet of Things
3	Image Processing
4	Biomaterials

List of available courses under Open Subject – II (L: 3; T:1; P:2; C:5)	
S. No.	Course Title
1	Artificial Intelligence
2	Quantum Computing
3	Cyber Security
4	Design Thinking

List of available courses under Open Subject – III (L: 3; T:1; P:2; C:5)	
S. No.	Course Title
1	Robotics
2	Virtual Reality
3	Data Sciences
4	Food and Nutrition Technology

List of available courses under Open Subject – IV (L: 2; T:1; P:0; C:3)	
S. No.	Course Title
1	Block chain
2	Bioterrorism and National Security

➤ **Open Subject – I**

Course Code	:	OS301
Course Title	:	3D Printing & Design
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The course is designed to impart knowledge and skills related to 3D printing technologies, selection of material and equipment and develop a product using this technique in the Industry 4.0 environment.

Course Content:

1. 3D Printing (Additive Manufacturing)

Introduction, Process, Classification, Advantages, Additive V/s Conventional Manufacturing processes, Applications.

2. CAD for Additive Manufacturing

CAD Data formats, Data translation, Data loss, STL format.

3. Additive Manufacturing Techniques

3.1 Stereo- Lithography, LOM, FDM, SLS, SLM, Binder Jet technology.

3.2 Process, Process parameter, Process Selection for various applications.

3.3 Additive Manufacturing Application Domains: Aerospace, Electronics, Health Care, Defence, Automotive, Construction, Food Processing, Machine Tools.

4. Materials

4.1 Polymers, Metals, Non-Metals, Ceramics

4.2 Various forms of raw material- Liquid, Solid, Wire, Powder; Powder Preparation and their desired properties, Polymers and their properties.

4.3 Support Materials

5. Additive Manufacturing Equipment

5.1 Process Equipment- Design and process parameters

5.2 Governing Bonding Mechanism

5.3 Common faults and troubleshooting

5.4 Process Design

6. Post Processing: Requirement and Techniques

7. Product Quality

7.1 Inspection and testing

7.2 Defects and their causes

Practicals

1. 3D Modelling of a single component.
2. Assembly of CAD modelled Components.
3. Exercise on CAD Data Exchange.
4. Generation of .stl files.
5. Identification of a product for Additive Manufacturing and its AM process plan.
6. Printing of identified product on an available AM machine.
7. Post processing of additively manufactured product.
8. Inspection and defect analysis of the additively manufactured product.
9. Comparison of Additively manufactured product with conventional manufactured counterpart.

Text Books/References:

1. Sabrie Soloman, “3D Printing and Design”, Khanna Publishing House, Delhi.
2. Ian Gibson, David W. Rosen and Brent Stucker, “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2010.
3. Andreas Gebhardt, “Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing”, Hanser Publisher, 2011.
4. CK Chua, Kah Fai Leong, “3D Printing and Rapid Prototyping- Principles and Applications”, World Scientific, 2017.
5. J.D. Majumdar and I. Manna, “Laser-Assisted Fabrication of Materials”, Springer Series in Material Science, 2013.
6. L. Lu, J. Fuh and Y.S. Wong, “Laser-Induced Materials and Processes for Rapid Prototyping”, Kulwer Academic Press, 2001.
7. Zhiqiang Fan and Frank Liou, “Numerical Modelling of the Additive Manufacturing (AM) Processes of Titanium Alloy”, InTech, 2012.

Course Outcomes: After completion of this course, the students will be able to:

- Develop CAD models for 3D printing.
- Import and Export CAD data and generate .stl file.
- Select a specific material for the given application.
- Select a 3D printing process for an application.
- Produce a product using 3D Printing or Additive Manufacturing (AM).

Course Code	:	OS303
Course Title	:	Internet of Things
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The objective of this course is to impart necessary and practical knowledge of components of the Internet of Things and develop the skills required to build real-life IoT based projects.

Course Content:

Introduction to IoT

Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals- Devices and gateways, Data management, Business processes in IoT, Everything as a Service(XaaS), Role of Cloud in IoT, Security aspects in IoT.

Elements of IoT

Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces.

Software Components- Programming API's (using Python/Node.js/Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.

IoT Application Development

Solution framework for IoT applications- Implementation of Device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices.

IoT Case Studies

IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Home Automation.

Practicals:

1. Familiarization with Arduino/Raspberry Pi and perform necessary software installation.
2. To interface LED/Buzzer with Arduino/Raspberry Pi and write a program to turn ON LED for 1 sec after every 2 seconds.
3. To interface Push button/Digital sensor (IR/LDR) with Arduino/Raspberry Pi and write a program to turn ON LED when push button is pressed or at sensor detection.
4. To interface DHT11 sensor with Arduino/Raspberry Pi and write a program to print temperature and humidity readings.
5. To interface motor using relay with Arduino/Raspberry Pi and write a program to turn ON motor when push button is pressed.
6. To interface OLED with Arduino/Raspberry Pi and write a program to print temperature and humidity readings on it.
7. To interface Bluetooth with Arduino/Raspberry Pi and write a program to send sensor data to smartphone using Bluetooth.
8. To interface Bluetooth with Arduino/Raspberry Pi and write a program to turn LED ON/OFF when '1'/'0' is received from smartphone using Bluetooth.
9. Write a program on Arduino/Raspberry Pi to upload temperature and humidity data to thingspeak cloud.
10. Write a program on Arduino/Raspberry Pi to retrieve temperature and humidity data from thingspeak cloud.
11. To install MySQL database on Raspberry Pi and perform basic SQL queries.
12. Write a program on Arduino/Raspberry Pi to publish temperature data to MQTT broker.
13. Write a program on Arduino/Raspberry Pi to subscribe to MQTT broker for temperature data and print it.

14. Write a program to create TCP server on Arduino/Raspberry Pi and respond with humidity data to TCP client when requested.
15. Write a program to create UDP server on Arduino/Raspberry Pi and respond with humidity data to UDP client when requested.

Text Books/References:

1. Vijay Madiseti, Arshdeep Bahga, "Internet of Things, "A Hands on Approach", University Press
2. Jeeva Jose, "Internet of Things", Khanna Publishing House, New Delhi, 2018.
3. Dr. SRN Reddy, Rachit Thukral and Manasi Mishra, "Introduction to Internet of Things: A practical Approach", ETI Labs
4. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press
5. Adrian McEwen, "Designing the Internet of Things", Wiley
6. Raj Kamal, "Internet of Things: Architecture and Design", McGraw Hill
7. Cuno Pfister, "Getting Started with the Internet of Things", O Reilly Media

Course Outcomes: After the completion of this course, the students will be able to:

- Understand the Internet of Things and its hardware and software components.
- Interface I/O devices, sensors & communication modules.
- Remotely monitor data and control devices.
- Develop real life IoT based projects.

Course Code	:	OS305
Course Title	:	Image Processing
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s):

1. To review image processing techniques for computer vision.
2. To understand shape and region analysis.
3. To understand Hough Transform and its applications to detect lines, circles, ellipses.
4. To understand three-dimensional image analysis techniques.
5. To understand motion analysis.
6. To study some applications of computer vision algorithms.

Course Content:

Unit I: Image Processing Foundations

Review of image processing techniques – classical filtering operations – thresholding techniques – edge detection techniques – corner and interest point detection – mathematical morphology – texture.

Unit II: Shapes and Regions

Binary shape analysis – connectedness – object labeling and counting – size filtering – distance functions – skeletons and thinning – deformable shape analysis – boundary tracking procedures – active contours – shape models and shape recognition – centroidal profiles – handling occlusion – boundary length measures – boundary descriptors – chain codes – Fourier descriptors – region descriptors – moments.

Unit III: Hough Transform

Line detection – Hough Transform (HT) for line detection – foot-of-normal method – line localization – line fitting – RANSAC for straight line detection – HT based circular object detection – accurate center location – speed problem – ellipse detection – Case study: Human Iris location – hole detection – generalized Hough Transform (GHT) – spatial matched filtering – GHT for ellipse detection – object location – GHT for feature collation.

Unit IV: 3D Vision and Motion

Methods for 3D vision – projection schemes – shape from shading – photometric stereo – shape from texture – shape from focus – active range finding – surface representations – point-based representation – volumetric representations – 3D object recognition – 3D reconstruction – introduction to motion – triangulation – bundle adjustment – translational alignment – parametric motion – spline-based motion – optical flow – layered motion.

Unit V: Applications

Application: Photo album – Face detection – Face recognition – Eigenfaces – Active appearance and 3D shape models of faces Application: Surveillance – foreground-background separation – particle filters – Chamfer matching, tracking, and occlusion – combining views from multiple cameras – human gait analysis Application: In-vehicle vision system: locating roadway – road markings – identifying road signs – locating pedestrians.

Practicals: May be designed by the course instructor based on the topics taught.

Text Books/References:

1. E. R. Davies, "Computer & Machine Vision", Fourth Edition, Academic Press, 2012.
2. R. Szeliski, "Computer Vision: Algorithms and Applications", Springer 2011.
3. Simon J. D. Prince, "Computer Vision: Models, Learning, and Inference", Cambridge University Press, 2012.
4. Mark Nixon and Alberto S. Aquado, "Feature Extraction & Image Processing for Computer Vision", Third Edition, Academic Press, 2012.
5. D. L. Baggio et al., "Mastering OpenCV with Practical Computer Vision Projects", Packt Publishing, 2012.
6. Jan Erik Solem, "Programming Computer Vision with Python: Tools and algorithms for analyzing images", O'Reilly Media, 2012.

Course Outcomes: Upon completion of the course, the students will be able to:

1. Implement fundamental image processing techniques required for computer vision.
2. Perform shape analysis.
3. Implement boundary tracking techniques.

4. Apply chain codes and other region descriptors.
5. Apply Hough Transform for line, circle, and ellipse detections.
6. Apply 3D vision techniques.
7. Implement motion related techniques.
8. Develop applications using computer vision techniques.

Course Code	:	OS307
Course Title	:	Biomaterials
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): Introduce students to various types of available biomaterials, their chemistry, and application.

Course Content: Introduction to Materials, General structure and properties. Classification of common materials and applications. Chemical Bonding, Crystalline, Amorphous. Melting, Solidification, Nucleation, Phase diagrams. Metal and alloys in Medical application: Stainless steel, cobalt based alloys, titanium based alloys (including shape memory alloys). Ceramics and glasses-bio ceramics: Type of Ceramics and their classification, Calcinations, Annealing, Sintering, Nearly inert ceramics, bio-reactive glasses and glass ceramics, Calcium phosphate ceramics. Introductions to polymers: Definition, classification, Polymerization. Rubber, plastics, fibers and resins and structure-properties relationship. Biodegradable polymers; Natural polymers, Composites, Pyrolytic carbon, Carbon nanotubes. Bulk Proper, Surface properties and modification of surface properties. Basic principles of engineering manufacturing, methods and applications of common manufacturing processes, milling, grinding, finishing, rolling, forging, Concept of biomimetic synthesis, Preparation of fiber and wire, Fabrication of Porous Materials, Direct molding Technique, Different advanced fabrication technique.

Laboratory Work:

1. Investment Casting of metal in foundry.
2. Wet chemical synthesis of hydroxyapatite (HA) $[Ca_{10}(PO_4)_6(OH)_2]$: Calcium Hydroxide and Orthophosphoric Acid Calcium Nitrate, Diammonium Hydrogen Phosphate and Ammonium Hydroxide.
3. Preparation of alumina dense and porous body.
4. Preparation of Hydroxyapatite dense and porous body.
5. Preparation of Dental crown, Acetabular cup and femoral head.
6. Preparation of bioglass foam and flake.
7. Metallography: Polishing of metal and ceramics, etching, microstructure evaluation using SEM, Optical microscopy.
8. XRD analysis.

9. Polymerization of methyl methacrylate, acrylate, acrylamide, Cross Linking, Rubber blending, vulcanization of rubber.
10. Preparation of composite using organic monomer-crosslinker and filler hydroxyapatite/alumina/silica nano powder.
11. Mechanical testing of metal, Ceramics and polymer (Tensile test for metal and polymer, Bending and crushing strength of ceramics dense component and porous component), Micro hardness testing.
12. Preparation of Ceramics nano fiber and their use in the fabrication of composite dental filler, Mechanical properties evaluation.
13. Metal Titanium: Surface modification; characterization of surface modified Ti; osteo conduction study; in vitro and in vivo study.

Text Books/References:

1. Biomaterials Science - An Introduction to Materials in Medicine, Buddy Ratner Allan Hoffman Frederick Schoen Jack Lemons, ISBN: 9780080470368, Academic Press, Published Date: 18th August 2004.
2. Biomaterials: An Introduction- J. Bo. Park.
3. Materials Science and Engineering- Callister.
4. Materials for Medical Engineering- Euromat 99 vol-2.

Course Outcomes: At the end of the course, students will know about chemistry and testing of various biomaterials.

➤ **Open Subject – II**

Course Code	:	OS302
Course Title	:	Artificial Intelligence
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): Artificial Intelligence is a major step forward in how computer system adapts, evolves and learns. It has widespread application in almost every industry and is considered to be a big technological shift, similar in scale to past events such as the industrial revolution, the computer age, and the smartphone revolution.

This course will allow gaining expertise in one of the most fascinating and fastest-growing areas of Computer Science through a classroom program that covers fascinating and compelling topics related to human intelligence and its applications in industry, defense, healthcare, agriculture, and many other areas. This course will give the students a rigorous, advanced and professional graduate-level foundation in Artificial Intelligence.

Course Contents:

1. Introduction

Concept of AI, history, current status, scope, agents, environments, Problem Formulations, Review of tree and graph structures, State space representation, Search graph and Search tree.

2. Search Algorithms

Random search, Search with closed and open list, Depth and Breadth first search, Heuristic search, Best first search, A* algorithm, Game Search.

3. Probabilistic Reasoning

Probability, conditional probability, Bayes Rule, Bayesian Networks- representation, construction and inference, temporal model, hidden Markov model.

4. Markov Decision process

MDP formulation, utility theory, utility functions, value iteration, policy iteration and partially observable MDPs.

5. Reinforcement Learning

Passive reinforcement learning, direct utility estimation, adaptive dynamic programming, temporal difference learning, active reinforcement learning- Q learning.

Practicals:

1. Write a programme to conduct uninformed and informed search.
2. Write a programme to conduct game search.
3. Write a programme to construct a Bayesian network from given data.
4. Write a programme to infer from the Bayesian network.
5. Write a programme to run value and policy iteration in a grid world.
6. Write a programme to do reinforcement learning in a grid world.
7. Mini Project work.

Text Books/References:

1. Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", 3rd Edition, Prentice Hall
2. Elaine Rich and Kevin Knight, "Artificial Intelligence", Tata McGraw Hill
3. Trivedi, M.C., "A Classical Approach to Artificial Intelligence", Khanna Publishing House, Delhi.
4. Saroj Kaushik, "Artificial Intelligence", Cengage Learning India, 2011
5. David Poole and Alan Mackworth, "Artificial Intelligence: Foundations for Computational Agents", Cambridge University Press 2010.

Websites:

1. <https://nptel.ac.in/courses/106105077>
2. <https://nptel.ac.in/courses/106106126>
3. <https://aima.cs.berkeley.edu>
4. https://ai.berkeley.edu/project_overview.html (for Practicals)

Course Outcomes: After undergoing this course, the students will be able to:

1. Build intelligent agents for search and games.
2. Solve AI problems through programming with Python.
3. Learning optimization and inference algorithms for model learning.

4. Design and develop programs for an agent to learn and act in a structured environment.

Course Code	:	OS304
Course Title	:	Quantum Computing
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The objective of this course is to impart the necessary knowledge to the learner so that he/she can develop and implement algorithms and write programs using these algorithms.

Course Content:

1. Introduction to Quantum Computing

- Motivation for studying Quantum Computing
- Major players in the industry (IBM, Microsoft, Rigetti, D-Wave etc.)
- Origin of Quantum Computing
- Overview of major concepts in Quantum Computing
 - Qubits and multi-qubits states, Bra-ket notation.
 - Bloch Sphere representation
 - Quantum Superposition
 - Quantum Entanglement

2. Math Foundation for Quantum Computing

Matrix Algebra: basis vectors and orthogonality, inner product and Hilbert spaces, matrices and tensors, unitary operators and projectors, Dirac notation, Eigenvalues and Eigenvectors.

3. Building Blocks for Quantum Program

- Architecture of a Quantum Computing platform
- Details of q-bit system of information representation:
 - Bloch Sphere
 - Multi-qubits States
 - Quantum superposition of qubits (valid and invalid superposition)
 - Quantum Entanglement
 - Useful states from quantum algorithmic perspective e.g. Bell State
 - Operation on qubits: Measuring and transforming using gates.
 - Quantum Logic gates and Circuit: Pauli, Hadamard, phase shift, controlled gates, Ising, Deutsch, swap etc.
- Programming model for a Quantum Computing Program
 - Steps performed on classical computer
 - Steps performed on Quantum Computer
 - Moving data between bits and qubits

4. Quantum Algorithms

- Basic techniques exploited by quantum algorithms.
 - Amplitude amplification
 - Quantum Fourier Transform
 - Phase Kick-back
 - Quantum Phase estimation
 - Quantum Walks
- Major Algorithms
 - Shor's Algorithm
 - Grover's Algorithm
 - Deutsch's Algorithm
 - Deutsch -Jozsa Algorithm
- OSS Toolkits for implementing Quantum program
 - IBM quantum experience
 - Microsoft Q
 - Rigetti PyQuil (QPU/QVM)

Practicals:

1. Building Quantum dice.
2. Building Quantum Random No. Generation.
3. Composing simple quantum circuits with q-gates and measuring the output into classical bits.
4. Implementation of Shor's Algorithms.
5. Implementation of Grover's Algorithm.
6. Implementation of Deutsch's Algorithm.
7. Implementation of Deutsch-Jozsa's Algorithm.
8. Mini Project such as implementing an API for efficient search using Grover's Algorithms or Integer factorization using Shor's Algorithm.

Text Books/References:

1. Michael A. Nielsen, "Quantum Computation and Quantum Information", Cambridge University Press.
2. David McMahon, "Quantum Computing Explained", Wiley.
3. IBM Experience: <https://quantumexperience.ng.bluemix.net>
4. Microsoft Quantum Development Kit <https://www.microsoft.com/en-us/quantum/development-kit>.
5. Forest SDK PyQuil: <https://pyquil.readthedocs.io/en/stable/>

Course Outcomes: At the end of this course, the students will be able to:

- Explain the working of a Quantum Computing program, its architecture and program model.
- Develop quantum logic gate circuits.
- Develop quantum algorithm.
- Program quantum algorithm on major toolkits.

Course Code	:	OS306
Course Title	:	Cyber Security
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The course has been designed to give students an extensive overview of cybersecurity issues, tools, and techniques that are critical in solving problems in cybersecurity domains. The course aims at providing students with concepts of computer security, cryptography, digital money, secure protocols, detection, and other security techniques. The course will help students to gauge understanding in essential techniques in protecting Information Systems, IT infrastructure, analyzing and monitoring potential threats and attacks, devising security architecture and implementing security solutions. The students will also have a wider perspective on information security from a national security perspective from both technology and legal perspective.

Course Content:

1. Cyber Security Concepts

Essential Terminologies: CIA, Risks, Breaches, Threats, Attacks, Exploits. Information Gathering (Social Engineering, Foot Printing & Scanning).

Open Source/ Free/ Trial Tools: nmap, zenmap, Port Scanners, Network scanners.

2. Cryptography and Cryptanalysis

Introduction to Cryptography, Symmetric key Cryptography, Asymmetric key Cryptography, Message Authentication, Digital Signatures, Applications of Cryptography. Overview of Firewalls- Types of Firewalls, User Management, VPN Security, Security Protocols: - security at the Application Layer- PGP and S/MIME, Security at the Transport Layer- SSL and TLS, Security at the Network Layer-IPSec.

Open Source/ Free/ Trial Tools: Implementation of Cryptographic techniques, OpenSSL, Hash Values Calculations MD5, SHA1, SHA256, SHA 512, Steganography (Stools).

3. Infrastructure and Network Security

Introduction to System Security, Server Security, OS Security, Physical Security, Introduction to Networks, Network packet Sniffing, Network Design Simulation. DOS/DDOS attacks. Asset Management and Audits, Vulnerabilities and Attacks. Intrusion detection and Prevention Techniques, Host based Intrusion Prevention Systems, Security Information Management, Network Session Analysis, System Integrity Validation.

Open Source/ Free/ Trial Tools: DOS Attacks, DDOS attacks, Wireshark, Cain & abel, iptables/ Windows Firewall, snort, suricata, fail2ban.

4. Cyber Security Vulnerabilities & Safe Guards

Internet Security, Cloud Computing & Security, Social Network sites security, Cyber Security Vulnerabilities-Overview, vulnerabilities in software, System administration, Complex Network Architectures, Open Access to Organizational Data, Weak Authentication, Authorization, Unprotected Broadband communications, Poor Cyber

Security Awareness. Cyber Security Safeguards- Overview, Access control, IT Audit, Authentication. Open Web Application Security Project (OWASP), Web Site Audit and Vulnerabilities assessment.

Open Source/ Free/ Trial Tools: WinAudit, Zap proxy (OWASP), burp suite, DVWA kit.

5. Malware

Explanation of Malware, Types of Malware: Virus, Worms, Trojans, Rootkits, Robots, Adware's, Spywares, Ransom wares, Zombies etc., OS Hardening (Process Management, Memory Management, Task Management, Windows Registry/ services another configuration), Malware Analysis.

Open Source/ Free/ Trial Tools: Antivirus Protection, Anti Spywares, System tuning tools, Anti Phishing.

6. Security in Evolving Technology

Biometrics, Mobile Computing and Hardening on android and ios, IOT Security, Web server configuration and Security. Introduction, Basic security for HTTP Applications and Services, Basic Security for Web Services like SOAP, REST etc., Identity Management and Web Services, Authorization Patterns, Security Considerations, Challenges.

Open Source/ Free/ Trial Tools: adb for android, xcode for ios, Implementation of REST/ SOAP web services and Security implementations.

7. Cyber Laws and Forensics

Introduction, Cyber Security Regulations, Roles of International Law, the state and Private Sector in Cyberspace, Cyber Security Standards. The INDIAN Cyberspace, National Cyber Security Policy 2013. Introduction to Cyber Forensics, Need of Cyber Forensics, Cyber Evidence, Documentation and Management of Crime Scene, Image Capturing and its importance, Partial Volume Image Web Attack Investigations, Denial of Service Investigations, Internet Crime Investigations, Internet Forensics, Steps for Investigating Internet Crime, Email Crime Investigations.

Open Source/ Free/ Trial Tools: Case Studies related to Cyber Law, Common Forensic Tools like dd, md5sum, sha1sum, Ram dump analysis, USB device.

Practicals:

1. Implementation to gather information from any PC's connected to the LAN using whois, port scanners, network scanning, Angry IP scanners etc.
2. Implementation of Symmetric and Asymmetric cryptography.
3. Implementation of Steganography.
4. Implementation of MITM- attack using wireshark/ network sniffers.
5. Implementation of Windows security using firewalls and other tools.
6. Implementation to identify web vulnerabilities, using OWASP project.
7. Implementation of IT Audit, malware analysis and Vulnerability assessment and generate the report.
8. Implementation of OS hardening and RAM dump analysis to collect the Artifacts and other information.
9. Implementation of Mobile Audit and generate the report of the existing Artifacts.
10. Implementation of Cyber Forensics tools for Disk Imaging, Data acquisition, Data extraction and Data Analysis and recovery.

Text Books/References:

1. William Stallings, "Cryptography and Network Security", Pearson Education/PHI, 2006.
2. V.K. Jain, "Cryptography and Network Security", Khanna Publishing House.
3. Gupta Sarika, "Information and Cyber Security", Khanna Publishing House, Delhi.
4. Atul Kahate, "Cryptography and Network Security", McGraw Hill.
5. V.K. Pachghare, "Cryptography and Information Security", PHI Learning
6. Nina Godbole, "Information System Security", Wiley
7. Bothra Harsh, "Hacking", Khanna Publishing House, Delhi.

Course Outcomes: After completion of this course, the students should be able to:

1. Understand, appreciate, employ, design and implement appropriate security technologies and policies to protect computers and digital information.
2. Identify & Evaluate Information Security threats and vulnerabilities in Information Systems and apply security measures to real time scenarios.
3. Identify common trade-offs and compromises that are made in the design and development process of Information Systems.
4. Demonstrate the use of standards and cyber laws to enhance information security in the development process and infrastructure protection.

Course Code	:	OS308
Course Title	:	Design Thinking
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The word "design" has traditionally been used to describe the visual aesthetics of objects such as consumer products, architecture, and fashion. Over time, the discipline of design has expanded to include not only the shaping of things but also the ways that people interact with systems, services, and organizations. Design Thinking is a problem-solving methodology especially well-suited for investigating ill-defined problems. It uses methods derived from the discipline of design to match people's needs with what is feasible and what a viable organizational strategy can convert into customer/stakeholder value in a financially sustainable way. It was initially proposed as a way for corporations to more quickly, creatively, and effectively develop new offerings but has since been further adapted to address issues in the public and social sectors as well. This course provides an introduction to design thinking.

Course Content:

Unit I - Introduction to Design thinking

1. Importance of design thinking in daily life;
2. Types of innovation in design
3. Skills required for designing products for end users;
4. Need for design thinking in entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Startup & Make in India);

5. Copyright possibilities for design.
6. Various practical applications of design thinking in industry verticals – product, process, research, finance, HR, marketing, operations, etc.

Unit II – Design thinking process

1. Scoping – list the requirements for the end users.
2. Identifying insights – spot user pain points in application situations.
3. Establish design criteria – various qualitative and quantitative parameters.
4. Concept development – to meet end user requirements.

Unit III - Design Strategy

1. Principles to design and build a prototype – use of computer aided tools for visual depiction.
2. Validation of assumptions & prototypes under simulated user conditions.
3. Re-design and customization to suit requirements.
4. Field survey of the design.
5. Costing & suitability to production requirements – availability of components, sourcing, quality, final build.

Unit IV - Marketing & promoting the design

1. Identification of customer segments for the designed products & processes.
2. Pitching methods to communicate the design elements.
3. Developing distribution channels – franchising to promote design;
4. Policies, promotion, advertising;
5. Branding and market linkages for “virtual startup company”.

Unit V – Knowledge Centers

1. Introduction to TED, Stanford India Bio design.
2. Various Indian and global institutions for design thinking support.
3. Tinkering labs in India – fix Atal Tinkering Lab, India STEM foundation.
4. Certifications in designs.

Laboratory Work:

1. Collecting user feedback.
2. Measurement of design objectives.
3. Prototyping design using computer tools.
4. Building and testing in application verticals.

Text Books/References:

1. Jeanne Liedtka and Tim Ogilvie Designing for Growth: A Design Thinking Tool Kit for Managers (Columbia University Press, 2011).
2. Jeanne Liedtka, Tim Ogilvie, and Rachel Brozenske, The Designing for Growth Field Book: A Step-by-Step Project Guide (Columbia University Press, 2014).
3. Human-Centered Design Toolkit (IDEO); <https://www.ideo.com/post/design-kit>
4. Design Thinking BootCamp Bootleg (Stanford D-School); <https://dschool.stanford.edu/resources/the-bootcamp-bootleg>
5. Collective Action Toolkit (frogdesign); https://www.frogdesign.com/wpcontent/uploads/2016/03/CAT_2.0_English.pdf

6. Design Thinking for Educators (IDEO):<https://designthinkingforeducators.com/>
7. Brown, Tim, and Barry Kätz. *Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation*. New York: Harper Business, 2009.
8. Cross, Nigel. *Design Thinking: Understanding How Designers Think and Work*. Oxford: Berg, 2011.
9. Bennett, Kevin. "Design Thinking: Creating a Better Understanding of Today to Get to a Better Tomorrow." *Forbes* (2013): n. pag. Web. 6 Apr. 2014. <http://www.forbes.com/sites/darden/2013/08/29/design-thinking-creating-a-better-understanding-of-today-to-get-to-a-better-tomorrow/>
10. Martin, Roger L. "The innovation catalysts." *Harvard Business Review* 89(6) (2011): 82-87.
11. "David Kelley: Human-centered design | Talk Video | TED." TED: Ideas worth spreading. N.p., n.d. Web. 4 Mar. 2014. https://www.ted.com/talks/david_kelley_on_human_centered_design?language=en

Course Outcomes: Introduce students to a domain called design thinking—that enhances innovation activities in terms of value creation, speed, and sustainability.

➤ **Open Subject – III**

Course Code	:	OS401
Course Title	:	Robotics
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The objective of this course is to impart knowledge about industrial robots for their control and design.

Course Content:

Introduction to Robotics

- Types and components of a robot, Classification of robots, closed-loop and open loop control systems.
- Kinematics systems; Definition of mechanisms and manipulators, Social issues and safety.

Robot Kinematics and Dynamics

- Kinematic Modelling: Translation and Rotation Representation, Coordinate transformation, DH parameters, Jacobian, Singularity, and Statics
- Dynamic Modelling: Equations of motion: Euler-Lagrange formulation

Sensors and Vision System

- Sensor: Contact and Proximity, Position, Velocity, Force, Tactile etc.

- Introduction to Cameras, Camera calibration, Geometry of Image formation, Euclidean/Similarity/Affine/Projective transformations
- Vision applications in robotics.

Robot Control

- Basics of control: Transfer functions, Control laws: P, PD, PID.
- Non-linear and advanced controls.

Robot Actuation Systems

Actuators: Electric, Hydraulic and Pneumatic; Transmission: Gears, Timing Belts and Bearings, Parameters for selection of actuators.

Control Hardware and Interfacing

Embedded systems: Architecture and integration with sensors, actuators, components, Programming for Robot Applications.

Practicals:

1. Study components of a real robot and its DH parameters.
2. Forward kinematics and validate using a software (Robo Analyser or any other free software tool).
3. Inverse kinematics of the real robot and validation using any software.
4. Use of open source computer vision programming tool openCV.
5. Image Processing using openCV.
6. Image Processing for color/shape detection.
7. Positioning and orientation of robot arm.
8. Control experiment using available hardware or software.
9. Integration of assorted sensors (IR, Potentiometer, strain gages etc.), micro controllers and ROS (Robot Operating System) in a robotic system.
10. Project work

Text Books/References:

1. Saha, S.K., "Introduction to Robotics, 2nd Edition, McGraw-Hill Higher Education, New Delhi, 2014.
2. Ghosal, A., "Robotics", Oxford, New Delhi, 2006.
3. Niku Saeed B., "Introduction to Robotics: Analysis, Systems, Applications", PHI, New Delhi.
4. Mittal R.K. and Nagrath I.J., "Robotics and Control", Tata McGraw Hill.
5. Mukherjee S., "Robotics Process Automation", Khanna Publishing House, Delhi.
6. Craig, J.J., "Introduction to Robotics: Mechanics and Control", Pearson, New Delhi, 2009
7. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, "Robot Modelling and Control", John Wiley and Sons Inc, 2005
8. Steve Heath, "Embedded System Design", 2nd Edition, Newnes, Burlington, 2003
9. Merzouki R., Samantaray A.K., Pathak P.M. and Bouamama B. Ould, "Intelligent Mechatronic System: Modeling, Control and Diagnosis", Springer.

Course Outcomes: After the completion of this course, the students will be able to:

- Perform kinematic and dynamic analyses with simulation.
- Design control laws for a robot.

- Integrate mechanical and electrical hardware for a real prototype of robotic device.
- Select a robotic system for a given application.

Course Code	:	OS403
Course Title	:	Virtual Reality
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The objective of this course is to provide a detailed understanding of the concepts of Virtual Reality and its applications.

Course Content:

1. Introduction to Virtual Reality

Virtual Reality and Virtual Environment: Introduction, Computer graphics, Real time computer graphics, Flight Simulation, Virtual environment requirement, benefits of virtual reality, Historical development of VR, Scientific Landmark.

3D Computer Graphics: Introduction, The Virtual world space, positioning the virtual observer, the perspective projection, human vision, stereo perspective projection, 3D clipping, Colour theory, Simple 3D modelling, Illumination models, Reflection models, Shading algorithms, Radiosity, Hidden Surface Removal, Realism-Stereographic image.

2. Geometric Modelling

Geometric Modelling: Introduction, From 2D to 3D, 3D space curves, 3D boundary representation.

Geometrical Transformations: Introduction, Frames of reference, Modelling transformations, Instances, Picking, Flying, Scaling the VE, Collision detection.

Generic VR system: Introduction, Virtual environment, Computer environment, VR technology, Model of interaction, VR Systems.

3. Virtual Environment

Animating the Virtual Environment: Introduction, The dynamics of numbers, Linear and Nonlinear interpolation, the animation of objects, linear and non-linear translation, shape & object inbetweening, free from deformation, particle system.

Physical Simulation: Introduction, Objects falling in a gravitational field, Rotating wheels, Elastic collisions, projectiles, simple pendulum, springs, Flight dynamics of an aircraft.

4. VR Hardware and Software

Human factors: Introduction, the eye, the ear, the somatic senses.

VR Hardware: Introduction, sensor hardware, Head-coupled displays, Acoustic hardware, Integrated VR systems.

VR Software: Introduction, Modelling virtual world, Physical simulation, VR toolkits, Introduction to VRML.

5. VR Applications

Introduction, Engineering, Entertainment, Science, Training.
The Future: Virtual environment, modes of interaction.

Practicals

1. Developing architecture of a house using Virtual Reality.
2. Perform CRO based experiment using Virtual Reality.
3. Undertaking qualitative analysis in Chemistry using Virtual Reality.
4. Carry out assembly/disassembly of an engine using Virtual Reality.
5. Explore human anatomy using Virtual Reality.
6. Simulation of circulation of blood in heart.
7. Simulation of Flight/Vehicle/Space Station.
8. Building Electronic circuit using Virtual Reality, given basic electronic components.
9. Developing concept of Virtual class room with multiplayer.

Text Books/References:

1. John Vince, "Virtual Reality Systems ", Pearson Education Asia, 2007.
2. Adams, "Visualizations of Virtual Reality", Tata McGraw Hill, 2000.
3. Grigore C. Burdea, Philippe Coiffet , "Virtual Reality Technology", Wiley Inter Science, 2 nd Edition, 2006.
4. William R. Sherman, Alan B. Craig, "Understanding Virtual Reality: Interface, Application and Design", Morgan Kaufmann, 2008.
5. www.vresources.org
6. www.vrac.iastate.edu
7. www.w3.org/MarkUp/VRM

Course Outcomes: At the end of the course, students will be able to:

1. Understand geometric modelling and Virtual environment.
2. Study about Virtual Hardware and Software
3. Develop Virtual Reality applications.

Course Code	:	OS405
Course Title	:	Data Sciences
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The objective of this course is to impart the necessary knowledge of the mathematical foundations needed for data science and develop programming skills required to build data science applications.

Course Content:

1. **Introduction to Data Science:** Concept of Data Science, Traits of Big data, Web Scraping, Analysis vs Reporting.

2. Introduction to Programming Tools for Data Science:

- 2.1 Toolkits using Python: Matplotlib, NumPy, Scikit-learn, NLTK
- 2.2 Visualizing Data: Bar Charts, Line Charts, Scatterplots
- 2.3 Working with data: Reading Files, Scraping the Web, Using APIs (Example: Using the Twitter APIs), Cleaning and Munging, Manipulating Data, Rescaling, Dimensionality Reduction

3. Mathematical Foundations

- 3.1 Linear Algebra: Vectors, Matrices.
- 3.2 Statistics: Describing a Single Set of Data, Correlation, Simpson's Paradox, Correlation and Causation.
- 3.3 Probability: Dependence and Independence, Conditional Probability, Bayes's Theorem, Random Variables, Continuous Distributions, The Normal Distribution, The Central Limit Theorem.
- 3.4 Hypothesis and Inference: Statistical Hypothesis Testing, Confidence Intervals, P Hacking, Bayesian Inference.

4. Machine Learning

Overview of Machine learning concepts – Over fitting and train/test splits, Types of Machine learning – Supervised, Unsupervised, Reinforced learning, Introduction to Bayes Theorem, Linear Regression- model assumptions, regularization (lasso, ridge, elastic net), Classification and Regression algorithms- Naïve Bayes, K-Nearest Neighbors, logistic regression, support vector machines (SVM), decision trees, and random forest, Classification Errors, Analysis of Time Series- Linear Systems Analysis, Nonlinear Dynamics, Rule Induction, Neural Networks Learning And Generalization, Overview of Deep Learning.

5. Case Studies of Data Science Application

Weather forecasting, Stock market prediction, Object recognition, Real Time Sentiment Analysis.

Practicals:

1. Write a programme in Python to predict the class of the flower based on available attributes.
2. Write a programme in Python to predict if a loan will get approved or not.
3. Write a programme in Python to predict the traffic on a new mode of transport.
4. Write a programme in Python to predict the class of user.
5. Write a programme in Python to identify the tweets which are hate tweets and which are not.
6. Write a programme in Python to predict the age of the actors.
7. Mini project to predict the time taken to solve a problem given the current status of the user.

Text Books/References:

1. Joel Grus, "Data Science from Scratch: First Principles with Python", O'Reilly Media
2. Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems", 1st Edition, O'Reilly Media

3. Jain V.K., “Data Science & Analytics: Using Python, R and SPSS Programming”, Khanna Publishing House, Delhi.
4. Jain V.K., “Big Data and Hadoop”, Khanna Publishing House, Delhi.
5. Jeeva Jose, “Introduction to Machine Learning using Python”, Khanna Publishing House, Delhi.
6. Chopra Rajiv, “Machine Learning”, Khanna Publishing House, Delhi.
7. Ian Goodfellow, Yoshua Bengio and Aaron Courville, "Deep Learning", MIT Press <http://www.deeplearningbook.org>
8. Jiawei Han and Jian Pei, "Data Mining Concepts and Techniques", Third Edition, Morgan Kaufmann Publishers.

Course Outcomes: At the end of this course, the students will be able to:

1. Demonstrate understanding of the mathematical foundations needed for data science.
2. Collect, explore, clean, munge and manipulate data.
3. Implement models such as k-nearest Neighbors, Naive Bayes, linear and logistic regression, decision trees, neural networks and clustering.
4. Build data science applications using Python based toolkits.

Course Code	:	OS407
Course Title	:	Food and Nutrition Technology
Number of Credits	:	5 (L: 3, T: 1, P: 2)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The objectives of this course are to acquaint the students with recent advances in biotechnology in foods to produce new products with desirable characteristics. These include characteristics such as disease and drought-resistant plants, leaner meat and enhanced flavor and nutritional quality of foods.

Course Content:

Module 1: Introduction to food biotechnology:

Introduction, History and scope of food Biotechnology, development and prospects of biotechnology in animal products, ancient and traditional food processing techniques; Biochemical and metabolic pathways of biological systems used in food production.

Module 2: Methods in food biotechnology:

Role of biotechnology in productivity of livestock, Modern biotechnological methods and processes in animal product development, chemical and physical factors required for growing microbial cultures in nutritive substrate; Meat species identification, Quality control, Screening products for contaminants.

Module 3: Biotechnology methods in food processing:

Use of biotechnology in the production of food additives, use of biotechnological tools for the processing and preservation and foods of animal origin, use of biotechnology improved enzymes in food processing industry, Basic principles of the industrial use of bio-reactions for production of biomass-upstream and downstream processing application of microorganisms as starter cultures in meat industry, microbial production of food ingredients; Biosensors and novel tools and their application in food science.

Module 4: Food safety & security:

Consumer concerns about risks and values, biotechnology & food safety, Ethical issues concerning GM foods; testing for GMOs; current guidelines for the production, release and movement of GMOs; Future and applications of food biotechnology in India.

Practicals:

1. Isolation of food borne bacteria (Campylobacter, Salmonella, Yersinia, E. coli) from various food sources using differential media.
2. Confirmation of food borne isolates by biotechnological tools.
3. Isolation and characterization of food borne viruses (rotavirus, hepatitis virus, polio virus, enterovirus) using biotechnological tools.

Text Books/References:

1. Potter, Norman. M. Food Science, 5th Ed. Springer US
2. Manay, S.; Shadakshara Swamy, M., (2004). Foods: Facts and Principles, 4th Ed. New Age Publishers.
3. B. Srilakshmi., (2002) Food Science, New Age Publishers.
4. Meyer, (2004). Food Chemistry. New Age
5. Deman JM. (1990) Principles of Food Chemistry. 2nd Ed. Van Nostrand Reinhold, NY
6. Ramaswamy H and Marcott M. Food Processing Principles and Applications. CRC Press

Course Outcomes: On completion of this course, students should have gained knowledge about recent advances in biotechnology related to food technology.

➤ **Open Subject – IV**

Course Code	:	OS409
Course Title	:	Block Chain
Number of Credits	:	3 (L: 2, T: 1, P: 0)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): The objective of this course is to provide a conceptual understanding of how blockchain technology can be used to innovate and improve business processes. The course covers the technological underpinning of block Chain operations in both theoretical and practical implementation of solutions using block Chain technology.

Course Content:

Introduction

Introduction: Overview of Block chain, Public Ledgers, Bitcoin, Smart Contracts, Block in a Block chain, Transactions, Distributed Consensus, Public vs Private Block chain, Understanding Crypto currency to Block chain, Permissioned Model of Block chain, Overview of Security aspects of BlockChain.

Basic Crypto Primitives: Cryptographic Hash Function, Properties of a hash function, Hash pointer and Merkle tree, Digital Signature, Public Key Cryptography, A basic cryptocurrency.

Understanding Block chain with Crypto currency

Bitcoin and Block chain: Creation of coins, Payments and double spending, Bitcoin Scripts, Bitcoin P2P Network, Transaction in Bitcoin Network, Block Mining, Block propagation and block relay.

Working with Consensus in Bitcoin: Distributed consensus in open environments, Consensus in a Bitcoin network, Proof of Work (PoW) – basic introduction, Hashcash PoW, Bitcoin PoW, Attacks on PoW and the monopoly problem, Proof of Stake, Proof of Burn and Proof of Elapsed Time, The life of a Bitcoin Miner, Mining Difficulty, Mining Pool.

Understanding Block chain for Enterprises

Permissioned Block chain: Permissioned model and use cases, Design issues for Permissioned block chains, Execute contracts, State machine replication, Overview of Consensus models for permissioned block chain- Distributed consensus in closed environment, Paxos, RAFT Consensus, Byzantine general problem, Byzantine fault tolerant system, Lamport-Shostak-Pease BFT Algorithm, BFT over Asynchronous systems.

Enterprise application of Block chain: Cross border payments, Know Your Customer (KYC), Food Security, Mortgage over Block chain, Block chain enabled Trade, We Trade – Trade Finance Network, Supply Chain Financing, Identity on Block chain.

Block chain application development

Hyperledger Fabric- Architecture, Identities and Policies, Membership and Access Control, Channels, Transaction Validation, Writing smart contract using Hyperledger Fabric, Writing smart contract using Ethereum, Overview of Ripple and Corda.

Practicals:

1. Install and understand Docker container, Node.js, Java and Hyperledger Fabric, Ethereum and perform necessary software installation on local machine/create instance on Cloud to run.
 - <https://github.com/hyperledger/>
 - <https://docs.docker.com/get-started/>
 - https://console.bluemix.net/docs/containers/container_index.html#container_index
2. Create and deploy a block chain network using Hyperledger Fabric SDK for Java Set up and initialize the channel, install and instantiate chaincode, and perform invoke and query on your block chain network

- (<https://developer.ibm.com/patterns/create-and-deploy-block-chain-network-using-fabric-sdk-java/>)
3. Interact with a block chain network. Execute transactions and requests against a block chain network by creating an app to test the network and its rules (<https://developer.ibm.com/patterns/interacting-with-a-block-chain-network/>)
 4. Deploy an asset-transfer app using block chain. Learn app development within a Hyperledger Fabric network (<https://developer.ibm.com/patterns/deploy-an-asset-transfer-app-using-block-chain/>)
 5. Use block chain to track fitness club rewards Build a web app that uses Hyperledger Fabric to track and trace member rewards (<https://developer.ibm.com/patterns/fitness-club-rewards-points-iot-and-retail-integration/>)
 6. Car auction network: A Hello World example with Hyperledger Fabric Node SDK and IBM Block Chain Starter Plan. Use Hyperledger Fabric to invoke chaincode while storing results and data in the starter plan (<https://developer.ibm.com/patterns/car-auction-network-hyperledger-fabric-node-sdk-starter-plan/>)
 7. Develop an IoT asset tracking app using Block chain. Use an IoT asset tracking device to improve a supply chain by using Block chain, IoT devices, and Node-RED (<https://developer.ibm.com/patterns/develop-an-iot-asset-tracking-app-using-block-chain/>)
 8. Secure art using block chain digital certificates. Node.js-based auction application can help democratize the art market (<https://developer.ibm.com/patterns/securing-art-using-block-chain-digital-certificates/>)
 9. Mini projects such as:
 - i. Block chain for telecom roaming, fraud, and overage management. See how communication service providers use block chain to enhance their value chains. <https://developer.ibm.com/patterns/block-chain-for-telecom-roaming-fraud-and-overagemanagement/>
 - ii. Use IoT dashboards to analyze data sent from a Block chain network. Build an IoT app and IoT dashboards with Watson IoT Platform and Node-RED to analyze IoT data sent from a Block chain network <https://developer.ibm.com/patterns/iot-dashboards-analyze-data-block-chain-network/>
 - iii. Create an Android app with Block chain integration. Build a Block chain enabled health and fitness app with Android and Kubernetes <https://developer.ibm.com/patterns/create-an-android-app-with-block-chain-integration/>
 - iv. Create a global finance block chain application with IBM Block chain Platform Extension for VS Code. Develop a Node.js smart contract and web app for a Global Finance with block chain use case <https://developer.ibm.com/patterns/global-financing-use-case-for-block-chain/>
 - v. Develop a voting application using Hyperledger and Ethereum. Build a decentralized app that combines Ethereum's Web3 and Solidity smart contracts with Hyperledger's hosting Fabric and Chaincode EVM <https://developer.ibm.com/patterns/voting-app-hyperledger-ethereum/>
 - vi. Create a block chain app for loyalty points with Hyperledger Fabric Ethereum Virtual Machine. Deploy Fabric locally with EVM and create a proxy for interacting with a smart contract through a Node.js web app <https://developer.ibm.com/patterns/loyalty-points-fabric-ethereum/>

Text Books/References:

1. Melanie Swan, “Block Chain: Blueprint for a New Economy”, O’Reilly, 2015
2. Josh Thompsons, “Block Chain: The BlockChain for Beginners- Guide to Block Chain Technology and Leveraging BlockChain Programming”
3. Daniel Drescher, “BlockChain Basics”, Apress; 1st edition, 2017
4. Anshul Kaushik, “BlockChain and Crypto Currencies”, Khanna Publishing House, Delhi.
5. Imran Bashir, “Mastering BlockChain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained”, Packt Publishing
6. Ritesh Modi, “Solidity Programming Essentials: A Beginner’s Guide to Build Smart Contracts for Ethereum and Block Chain”, Packt Publishing
7. Salman Baset, Luc Desrosiers, Nitin Gaur, Petr Novotny, Anthony O’Dowd, Venkatraman Ramakrishna, “Hands-On Block Chain with Hyperledger: Building Decentralized Applications with Hyperledger Fabric and Composer”, Import, 2018.

Course Outcomes: At the end of this course, the students will be able to:

- Understand block chain technology.
- Develop block chain based solutions and write smart contract using Hyperledger Fabric and Ethereum frameworks.
- Build and deploy block chain application for on premise and cloud based architecture.
- Integrate ideas from various domains and implement them using block chain technology in different perspectives.

Course Code	:	OS411
Course Title	:	Bioterrorism and National Security
Number of Credits	:	3 (L: 2, T: 1, P: 0)
Course Category	:	OS
Continuous Assessment (C.A.)	:	25
End Semester Assessment (E.S.A.)	:	75

Course Objective(s): Familiarization of issues involved and threats facing society due to bioterrorism and approaches to tackle it effectively.

Course Content:

Terrorism and Bioterrorism

Definition-Traditional Terrorists-New Terrorists-Nuclear, chemical, and radiological weapons-The psychology of Bioterrorism-Historical perspective.

Microbes and Immune System

Primary classes of Microbes-bacteria, virus, and other Agents-Immune system-Interaction between microbes and the immune system.

Bioterrorism Weapons and Techniques

Characteristics of microbes and the reasons for their Use-Symptoms-Pathogenicity-Epidemiology-natural and targeted release-The biological, techniques of dispersal, and case studies of Anthrax, Plague-Botulism, Smallpox, and Tularemia and VHF.

Prevention and Control of Bioterrorism

Surveillance and detection- Detection equipment and sensors –Diagnosis-Treatment-Vaccinations-Supplies- Effectiveness-Liability-Public Resistance-Response-First Responders-Infectious Control-Hospital-Prevention- Protection-Decontamination-Notification-Role of Law Enforcement-Economic impact.

Bioterrorism Management

Ethical issues: personal, national, the need to inform the public without creating fear, cost-benefit Rations-Information Management-Government control and industry Support-Microbial forensics.

Text Books:

1. Bioterrorism: Guidelines for Medical and Public Health Management, Henderson, Donald, American Medical Association, 1st Edition, 2002.
2. Biological Weapons: Limiting the Threat (BCSIA Studies in International Security), Lederberg, Joshua (Editor), MIT Press ,1999.
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Course Outcomes: Exposure to threats for national security, methods to tackle them and support law enforcement & health agencies to handle them.

Appendix – III

A Guide to Induction Program

Appendix – III: A Guide to Induction Program

1. Introduction

(Induction Program was discussed and approved for all colleges by AICTE in March 2017. It was discussed and accepted by the Council of IITs for all IITs in August 2016. It was originally proposed by a Committee of IIT Directors and accepted at the meeting of all IIT Directors in March 2016.¹ This guide has been prepared based on the Report of the Committee of IIT Directors and the experience gained through its pilot implementation in July 2016 as accepted by the Council of IITs. Purpose of this document is to help institutions in understanding the spirit of the accepted Induction Program and implementing it.)

Engineering colleges were established to train graduates well in the branch/department of admission, have a holistic outlook, and have a desire to work for national needs and beyond.

The graduating student must have knowledge and skills in the area of his study. However, he must also have broad understanding of society and relationships. Character needs to be nurtured as an essential quality by which he would understand and fulfill his responsibility as an engineer, a citizen and a human being. Besides the above, several meta-skills and underlying values are needed.

There is a mad rush for engineering today, without the student determining for himself his interests and his goals. This is a major factor in the current state of demotivation towards studies that exists among UG students.

The success of gaining admission into a desired institution but failure in getting the desired branch, with peer pressure generating its own problems, leads to a peer environment that is demotivating and corrosive. Start of hostel life without close parental supervision at the same time, further worsens it with also a poor daily routine.

To come out of this situation, a multi-pronged approach is needed. One will have to work closely with the newly joined students in making them feel comfortable, allow them to explore their academic interests and activities, reduce competition and make them work for excellence, promote bonding within them, build relations between teachers and students, give a broader view of life, and build character.

¹A Committee of IIT Directors was setup in the 152nd Meeting of IIT Directors on 6th September 2015 at IIT Patna, on how to motivate undergraduate students at IITs towards studies, and to develop verbal ability. The Committee submitted its report on 19th January 2016. It was considered at the 153rd Meeting of all IIT Directors at IIT Mandi on 26 March 2016, and the accepted report came out on 31 March 2016. The Induction Program was an important recommendation, and its pilot was implemented by three IITs, namely, IIT(BHU), IIT Mandi and IIT Patna in July 2016. At the 50th meeting of the Council of IITs on 23 August 2016, recommendation on the Induction Program and the report of its pilot implementation were discussed and the program was accepted for all IITs.

2. Induction Program

When new students enter an institution, they come with diverse thoughts, backgrounds and preparations. It is important to help them adjust to the new environment and inculcate in them the ethos of the institution with a sense of larger purpose. Precious little is done by most of the institutions, except for an orientation program lasting a couple of days.

We propose a 3-week long induction program for the UG students entering the institution, right at the start. Normal classes start only after the induction program is over. Its purpose is to make the students feel comfortable in their new environment, open them up, set a healthy daily routine, create bonding in the batch as well as between faculty and students, develop awareness, sensitivity and understanding of the self, people around them, society at large, and nature.²

The time during the Induction Program is also used to rectify some critical lacunas, for example, English background, for those students who have deficiency in it.

The following are the activities under the induction program in which the student would be fully engaged throughout the day for the entire duration of the program.

²*Induction Program as described here borrows from three programs running earlier at different institutions: (1) Foundation Program running at IIT Gandhinagar since July 2011, (2) Human Values course running at IIIT Hyderabad since July 2005, and (3) Counselling Service or mentorship running at several IITs for many decades. Contribution of each one is described next.*

IIT Gandhinagar was the first IIT to recognize and implement a special 5-week Foundation Program for the incoming 1st year UG students. It took a bold step that the normal classes would start only after the five week period. It involved activities such as games, art, etc., and also science and other creative workshops and lectures by resource persons from outside.

IIIT Hyderabad was the first one to implement a compulsory course on Human Values. Under it, classes were held by faculty through discussions in small groups of students, rather than in lecture mode. Moreover, faculty from all departments got involved in conducting the group discussions under the course. The content is non-sectarian, and the mode is dialogical rather than sermonising or lecturing. Faculty were trained beforehand, to conduct these discussions and to guide students on issues of life.

Counselling at some of the IITs involves setting up mentor-mentee network under which 1st year students would be divided into small groups, each assigned a senior student as a student guide, and a faculty member as a mentor. Thus, a new student gets connected to a faculty member as well as a senior student, to whom he/she could go to in case of any difficulty whether psychological, financial, academic, or otherwise. The Induction Program defined here amalgamates all the three into an integrated whole, which leads to its high effectiveness in terms of building physical activity, creativity, bonding, and character. It develops sensitivity towards self and one's relationships, builds awareness about others and society beyond the individual, and also in bonding with their own batch-mates and a senior student besides a faculty member.

Scaling up the above amalgamation to an intake batch of 1000 plus students was done at IIT(BHU), Varanasi starting from July 2016.

2.1. Physical Activity

This would involve a daily routine of physical activity with games and sports. It would start with all students coming to the field at 6 am for light physical exercise or yoga. There would also be games in the evening or at other suitable times according to the local climate. These would help develop team work. Each student should pick one game and learn it for three weeks. There could also be gardening or other suitably designed activity where labour yields fruits from nature.

2.2. Creative Arts

Every student would choose one skill related to the arts whether visual arts or performing arts. Examples are painting, sculpture, pottery, music, dance etc. The student would pursue it every day for the duration of the program.

These would allow for creative expression. It would develop a sense of aesthetics and also enhance creativity which would, hopefully, flow into engineering design later.

2.3. Universal Human Values

It gets the student to explore oneself and allows one to experience the joy of learning, stand up to peer pressure, take decisions with courage, be aware of relationships with colleagues and supporting staff in the hostel and department, be sensitive to others, etc. Need for character building has been underlined earlier. A module in Universal Human Values provides the base.

Methodology of teaching this content is extremely important. It must not be through do's and don'ts, but get students to explore and think by engaging them in a dialogue. It is best taught through group discussions and real life activities rather than lecturing. The role of group discussions, however, with clarity of thought of the teachers cannot be over emphasized. It is essential for giving exposure, guiding thoughts, and realizing values.

The teachers must come from all the departments rather than only one department like HSS or from outside of the Institute. Experiments in this direction at IIT(BHU) are noteworthy and one can learn from them.³

Discussions would be conducted in small groups of about 20 students with a faculty mentor each. It is to open thinking towards the self. Universal Human Values discussions could even continue for rest of the semester as a normal course, and not stop with the induction program.

Besides drawing the attention of the student to larger issues of life, it would build relationships between teachers and students which last for their entire 4-year stay and possibly beyond.

³The Universal Human Values Course is a result of a long series of experiments at educational institutes starting from IIT-Delhi and IIT Kanpur in the 1980s and 1990s as an elective course, NIT Raipur in late 1990s as a compulsory one-week off campus program. The courses at IIT(BHU) which started from July 2014, are taken and developed from two compulsory courses at IIIT Hyderabad first introduced in July 2005.

2.4. Literary

Literary activity would encompass reading, writing and possibly, debating, enacting a play etc.

2.5. Proficiency Modules

This period can be used to overcome some critical lacunas that students might have, for example, English, computer familiarity etc. These should run like crash courses, so that when normal courses start after the induction program, the student has overcome the lacunas substantially. We hope that problems arising due to lack of English skills, wherein students start lagging behind or failing in several subjects, for no fault of theirs, would, hopefully, become a thing of the past.

2.6. Lectures by Eminent People

This period can be utilized for lectures by eminent people, say, once a week. It would give the students exposure to people who are socially active or in public life.

2.7. Visits to Local Area

A couple of visits to the landmarks of the city, or a hospital or orphanage could be organized. This would familiarize them with the area as well as expose them to the under privileged.

2.8. Familiarization to Dept./Branch & Innovations

The students should be told about different method of study compared to coaching that is needed at IITs. They should be told about what getting into a branch or department means what role it plays in society, through its technology. They should also be shown the laboratories, workshops & other facilities.

3. Schedule

The activities during the Induction Program would have an Initial Phase, a Regular Phase and a Closing Phase. The Initial and Closing Phases would be two days each.

3.1. Initial Phase

Day	Time	Activity
Day 0	Whole Day	Students Arrive – Hostel Allotment (Preferably do pre-allotment)
Day 1	09:00 AM – 03:00 PM	Academic Registration
	04:30 PM – 06:00 PM	Orientation
Day 2	09:00 AM – 10:00 AM	Diagnostic test (for English etc.)
	10:00 AM – 12:25 PM	Visit to respective depts.
	12:30 PM – 01:55 PM	Lunch
	02:00 PM – 02:55 PM	Director’s address
	03:00 PM – 03:30 PM	Interaction with parents
	03:30 PM – 05:00 PM	Mentor-Mentee Groups - Introduction within group. (Same as Universal Human Values Group)

3.2. Regular Phase

After two days is the start of the Regular Phase of Induction. With this phase there would be regular program to be followed every day.

3.2.1. Daily Schedule

Some of the activities are on a daily basis, while some others are at specified periods within the Induction Program. We first show a typical daily timetable.

DAY 3 Onwards

Session	Time	Activity	Remarks
	06:00 AM	Wake up Call	
I	06:30 AM – 07:10 AM	Physical Activity (Mild Exercise / Yoga)	
	07:15 AM – 08:55 AM	Bath, Breakfast etc.	
II	09:10 AM – 10:55 AM	Creative Arts / Universal Human Values	Half the groups do creative arts
III	11:00 AM – 12:55 PM	Creative Arts / Universal Human Values	Complementary Alternate Groups
	01:00 PM – 02:25 PM	Lunch	
IV	02:30 PM – 03:55 PM	Afternoon Session	See below
V	04:00 PM – 05:00 PM	Afternoon Session	See below
	05:00 PM – 05:25 PM	Break / Light Tea	
VI	05:30 PM – 06:45 PM	Games / Special Lectures	
	06:50 PM – 08:25 PM	Rest and Dinner	
VII	08:30 PM – 09:25 PM	Informal Interactions (In hostels)	

Sundays are off. Saturdays have the same schedule as above or have outings.

3.2.2. Afternoon Activities (Non-Daily)

The following five activities are scheduled at different times of the Induction Program, and are not held daily for everyone:

1. Familiarization to Dept./Branch & Innovations
2. Visits to Local Area
3. Lectures by Eminent People
4. Literary
5. Proficiency Modules

Here is the approximate activity schedule for the afternoons (may be changed to suit local needs):

Session	Activity	Remarks
IV	Familiarization with Dept./Branch & Innovations	For 3 Days (Day 3 to Day 5)
IV, V and VI	Visit to Local Area	For 3 Days – interspersed (e.g. Saturdays)

IV	Lectures by Eminent People	As scheduled 3-5 lectures
IV	Literary (Play / Literature / Book Reading)	For 3-5 Days
V	Proficiency Modules	Daily, but only for those who need it.

3.3. Closing Phase

Day	Time	Activity
Last But One Day	08:30 AM – 12:00 PM	Discussions and finalization of presentation within each group
	02:00 AM -05:00 PM	Presentation by each group in front of 4 other groups besides their own (about 100 students)
Last Day	Whole Day	Examinations (if any). May be extended to last 2 days, in case needed.

3.4. Follow Up after Closure

A question comes up as to what would be the follow up program after the formal 3-week Induction Program is over? The groups which are formed should function as mentor-mentee network. A student should feel free to approach his faculty mentor or the student guide, when facing any kind of problem, whether academic or financial or psychological etc. (For every 10 undergraduate first year students, there would be a senior student as a student guide, and for every 20 students, there would be a faculty mentor.) Such a group should remain for the entire 4-5-year duration of the stay of the student. Therefore, it would be good to have groups with the students as well as teachers from the same department/discipline⁴.

Here we list some important suggestions which have come up and which have been experimented with:

3.4.1. Follow Up after Closure – Same Semester

It is suggested that the groups meet with their faculty mentors once a month, within the semester after the 3-week Induction Program is over. This should be a scheduled meeting shown in the timetable. (The groups are of course free to meet together on their own more often, for the student groups to be invited to their faculty mentor's home for dinner or tea, nature walk, etc.)

3.4.2. Follow Up – Subsequent Semesters

It is extremely important that continuity be maintained in subsequent semesters. It is suggested that at the start of the subsequent semesters (up to fourth semester), three days be set aside for three full days of activities related to follow up to Induction Program. The students be shown inspiring films, do collective art work, and group discussions be conducted. Subsequently, the groups should meet at least once a month.

4. Summary

Engineering institutions were set up to generate well trained manpower in engineering with a feeling of responsibility towards oneself, one's family, and society. The incoming undergraduate students are driven by their parents and society to join engineering without understanding their own interests and talents. As a result, most students fail to link up with the goals of their own institution.

The graduating student must have values as a human being, and knowledge and meta-skills related to his/her profession as an engineer and as a citizen. Most students who get demotivated to study engineering or their branch, also lose interest in learning.

The Induction Program is designed to make the newly joined students feel comfortable, sensitize them towards exploring their academic interests and activities, reducing competition and making them work for excellence, promote bonding within them, build relations between teachers and students, give a broader view of life, and building of character.

The Universal Human Values component, which acts as an anchor, develops awareness and sensitivity, feeling of equality, compassion and oneness, draw attention to society and nature, and character to follow through. It also makes them reflect on their relationship with their families and extended family in the college (with hostel staff and others). It also connects students with each other and with teachers so that they can share any difficulty they might be facing and seek help.

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