Syllabus for Bachelor of Technology
In
Dyestuff Technology

(Under the National Education Policy, NEP 2020)
(2023-2024)

Department of Speciality Chemicals Technology
INSTITUTE OF CHEMICAL TECHNOLOGY
(University Under Section-3 of UGC Act, 1956)
Elite Status and Center for Excellence
Government of Maharashtra

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A. Preamble

The undergraduate programmes at the Institute of Chemical Technology are reputed worldwide. Alumni from these programmes have found a place of pride in the Indian chemical industry including some top names and many as entrepreneurs, in Universities/ Institutes and Research Organization's throughout India and the world. The B.Tech. programmes in the then Department of Chemical Technology, University of Mumbai started in 1934 as post B.Sc., second graduation as B.Sc. (Tech.). Keeping national, societal needs in focus, post-independence, the programme grew into multiple branches keeping connection with chemical engineering content. Once the Institute became a university in 2009, these became independent B. Tech. Programmes retaining their dual core nature. The Institute of Chemical Technology is committed to keeping its syllabi updated and globally relevant for the industry. We have revamped the syllabi of all the B. Tech. programmes now in 2023 as per NEP 2020. The 176-credit programme each has the following Credit Distribution.

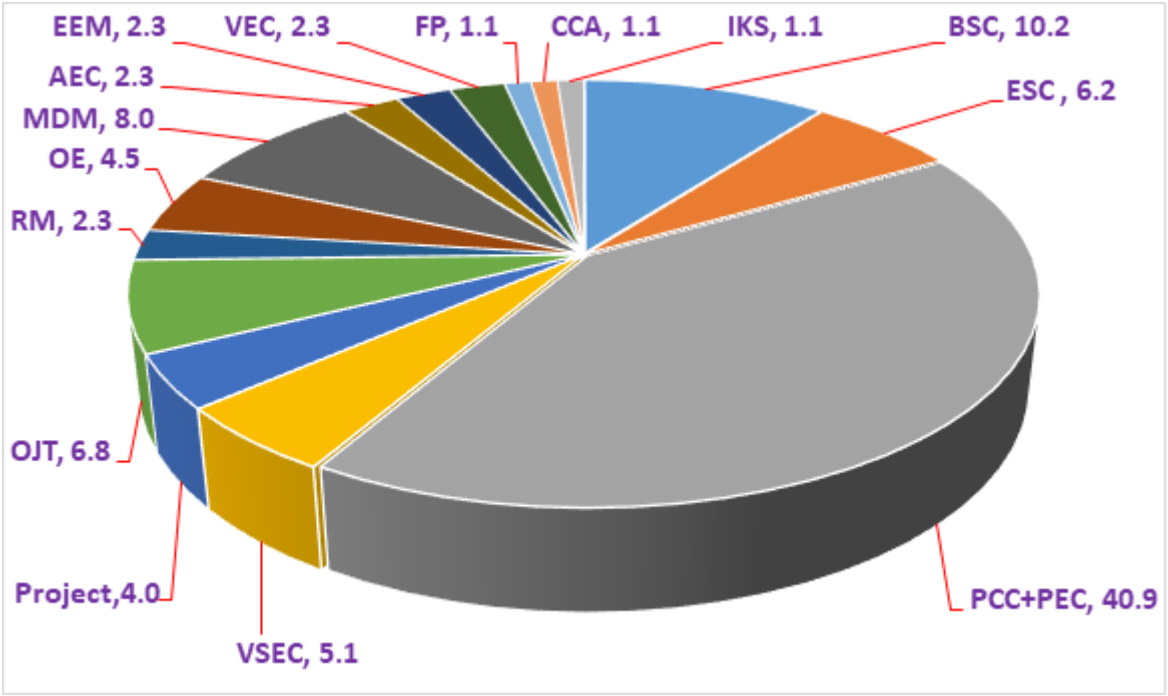

Figure 1 Distribution of various course types (in percentage) for the programme as per the guidelines of NEP 2020. This distribution does not include Honours courses having 18 credits in total.

All the courses are credit based and the evaluations are grade based. The credit system is a systematic way of describing an educational programme by attaching credits to its components. The definition of credits is based on student workload, learning outcomes and contact hours. This system is described in detail in Regulation No.9 of the Institute. Each theory course consists of Lectures and tutorials. During tutorial session, it is expected that the problem solving / case studies / relevant real-life applications/ student presentations / home assignments/individual or group projects are discussed in the presence of the teacher. Teachers can have the freedom to interchange lectures / tutorials depending upon the topic. The institute gives emphasis on continuous evaluation with considerable freedom to the teacher in deciding the mode of evaluation.

A. Programme Educational Objectives for B. Tech Dyestuff Technology

PEO1	**Successful Career**	Graduates from the programme will have successful careers in dyestuff and allied industries at various levels of management
PEO2	**Higher Study**	Graduates from the programme will pursue higher study related to organic chemistry and technology and allied disciplines in premier institutions across the world and make a career in academics or research
PEO3	**Multi-disciplinary Skills**	Graduates from the programme will work in a multi-disciplinary environment in the domain of intermediates & dyestuff technology

B. Program Outcomes as defined by the National Board of Accreditation (NBA): 12 Graduate Attributes

PO1	**Engineering knowledge**	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
PO2	**Problem analysis**	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
PO3	**Design/development of solutions**	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
PO4	**Conduct investigations of complex problems**	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
PO5	**Modern tool usage**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations
PO6	**The engineer and society**	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice
PO7	**Environment and sustainability**	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development
PO8	**Ethics**	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
PO9	**Individual and teamwork**	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
PO11	**Project management and finance**	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments
PO12	**Life-long learning**	Recognize the need for and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change

C. Programme Specific Outcomes (PSOs) for B. Tech Dyestuff Technology

The graduates will be able to:

PSO1	Understand terminology, basic concepts of science, mathematics, and fundamentals of engineering and technology particularly in dyestuff technology.
PSO2	Know about the concept of dyestuff chemistry and analysis, formulation processes to meet the specified needs considering feasibility, safety, health hazards, societal, economic, and environmental or sustainability factors as well as critically analyse relationships between these factors in the field of dyestuff technology.
PSO3	Probe and investigate to conduct experiments, research, or model as per standards, collect and analyse information based on field visits, analysis, and interpretation of data to prepare the valid technical project reports
PSO4	Apply basic science, engineering and dyestuff chemistry and technology knowledge in various sectors of industry, environment, life, and society, as well as develop solutions to complex molecules and its formulation applying principles and knowledge gained throughout the program or to develop new knowledge or methodologies through research
PSO5	Furnish to the needs of dyestuff industry, research organizations and academic institutes. set-up their own ventures and generate employment, promote awareness in society about dyestuff technology profession

EXIT Policy

Based on the National Education Policy guidelines (NEP-2020), the following rules and regulations shall be applicable for the exit from the Degree program where the candidate is currently registered, after the First year, Second Year, and Third Year of the students can exit at each level of their four-year B.Tech Dyestuff Technology program.

a) A candidate who has earned a total of 44 credits after the First year of the Degree Course AND completed eight weeks of practical training can exit the degree course with a Certificate in a relevant degree program.
b) A candidate who has earned a total of 88 credits after the Second year of the Degree Course AND has completed eight weeks of practical training/Internship can exit the degree course with Diploma in a relevant degree program.
c) A candidate who has earned a total of 132 credits after the Third year of the Degree course AND has completed eight weeks of practical training/ Internship can exit the degree with B.Sc (Tech) in a relevant degree program.
d) The candidate shall apply for the exit from the program by this exit policy in a standard format. The letter will be addressed to The Dean, Academic Program. The exit will be permitted only on completion of the training program as prescribed by the Regulations.

Sr. No.	Exit Year	Mandatory Activity	Credits	Duration (No of Weeks)
1	1st Year (After Semester II)	8 credit course workshop/chemistry lab (after semester 2)	8	8 weeks
2	2nd Year (After Semester IV)	Certificate Course in Practice of Chemical Technology of ICT (CCPCT)	8	8 weeks
3	3rd Year (After Semester VI)	In-plant training for 3 months	8	8 weeks

Syllabus Structure for
Bachelor of Technology in Dyestuff Technology

SEMESTER – I										
Subject Code	Subject	Course Type	Credits	Hrs/Week			Marks for various Exams			
				L	T	P	CA	MS	ES	Total
CHT1405	Physical Chemistry	BSC	3	2	1	0	20	30	50	100
CHT1406	Analytical Chemistry	BSC	3	2	1	0	20	30	50	100
MAT1301	Engineering Mathematics	ESC	3	2	1	0	20	30	50	100
PYT1205	Applied Physics	BSC	2	1	1	0	20	30	50	100
GEP1129	Engineering Graphics and Computer Aided Drafting	VSEC	3	1	0	4	20	30	50	100
DYT1011	**SPL-1:** A Primer on Technology of Intermediates and Dyestuffs	ESC	2	1	1	0	20	30	50	100
HUP1110B	Communication Skills (English)	AEC	2	0	0	4	50	0	50	100
HUPXXXX	OPEN Activity - Sports/ Fine arts/Yoga/ Music/NSS**	CCA	2	0	0	4	50	0	50	100
PYP1101	Physics Laboratory	BSC	2	0	0	4	50	0	50	100
	Total		**22**	**9**	**5**	**16**	-	-	-	900

SEMESTER – II										
Subject Code	Subject	Course Type	Credits	Hrs/Week			Marks for various Exams			
				L	T	P	CA	MS	ES	Total
CHT1407	Organic Chemistry	BSC	3	2	1	0	20	30	50	100
CHT1408	Industrial Chemistry	BSC	3	2	1	0	20	30	50	100
DYT1021	**SPL-2**: Physical and Chemical Constitution of Colorants	PCC	2	1	1	0	20	30	50	100
GET1306	Basic Mechanical Engineering	ESC	2	1	1	0	20	30	50	100
GET1125	Electrical Engineering and Electronics	ESC	2	1	1	0	20	30	50	100
CEP1720	Process Calculations	ESC	2	0	0	4	50	0	50	100
HUPXXXX	OPEN Activity- Sports/ Fine Arts/Yoga/ Music/NSS**	CCA	2	0	0	4	50	0	50	100
HUT1117	**MOOCs**/Indian Knowledge System	IKS	2	2	0	0	20	30	50	100
CHP1343	Physical and Analytical Chemistry Laboratory	BSC	2	0	0	4	50	0	50	100
CHP1132	Organic Chemistry Laboratory	VSEC	2	0	0	4	50	0	50	100

	Total		**22**	**7**	**5**	**20**	-	-	-	1000

Note:

- Universal Human Values (UHV) an audit course to be taken in inter-semester break after Semester – II to be taken as MOOC course.
- ** Students will undertake these co-curricular activities such as sports / Fine Arts / Yoga / Music / Literature etc. administered through various clubs under Technological Association approved by Dean, Students Affairs.

SEMESTER-III										
Subject Code	Subject	Course Type	Credits	Hrs/Week			Marks for various Exams			
				L	T	P	CA	MS	ES	Total
DYT1031	**SPL-3:** Technology of Benzenoid Intermediates	PCC	4	3	1	0	20	30	50	100
DYT1041	**SPL-4:** Quinonoid Intermediates - Chemistry and Technology	PCC	2	1	1	0	20	30	50	100
HUTXXXX	From Basic Sciences (Chemistry/ Physics/Biology / Maths / Humanities)	OE	4	3	1	0	20	30	50	100
HUPXXXX	Modern Indian Language (Marathi / Hindi or Any other language will be chosen)	AEC	2	0	0	4	50	0	50	100
HUT1205	Basic Economics and Finance	EEM	2	1	1	0	20	30	50	100
XXXXXXX	Value Enhancement in Emerging Areas (NPTEL)	VEC	2	1	1	0	20	30	50	100
XXXXXX	**MDM-I**	MDM	2	1	1	0	20	30	50	100
DYP1111	**Pr-1**: Lab-1: Analysis of Inorganic Raw Materials used in Colorant Industries	PCC	2	0	0	4	50	0	50	100
DYP1121	**Pr-2**: Lab 2: Chromatographic Methods and Analysis	PCC	2	0	0	4	50	0	50	100
	Total		**22**	**10**	**6**	**12**	-	-	-	900

SEMESTER – IV										
Subject Code	Subject	Course Type	Credits	Hrs/Week			Marks for various Exams			
				L	T	P	CA	MS	ES	Total
CET1105	Transport Phenomena	PCC	4	3	1	0	20	30	50	100
DYT1051	**SPL-5**: Technology of Naphthalene Intermediates	PCC	3	2	1	0	20	30	50	100
DYT1061	**SPL-6**: Technology of Ionic Dyes – I	PCC	3	2	1	0	20	30	50	100
XXXXXXX	From Basic Sciences (Chemistry/ Physics/	OE	2	1	1	0	20	30	50	100

	Biology / Maths) or Humanities Discipline									
CET1805	Chemical Process Economics	EEM	2	1	1	0	20	30	50	100
HUT1206	Environmental Sciences and Technology	VEC	2	1	1	0	20	30	50	100
XXXXXX	**MDM-II**	MDM	2	1	1	0	20	30	50	100
HUPXXXX	Community Engagement Projects#	CEP/ FP	2	0	0	4	50	0	50	100
DYP1131	**Pr-3**: Lab-3: Preparation of Intermediates	VSEC	2	0	0	4	50	0	50	100
	Total		**22**	**11**	**7**	**8**	-	-	-	900

Note: # During summer vacation, students will undertake community projects as individual or group related to study of societal technological activities through various organization such as Lions club, Teach India, Marathi Vidnyan Parishad, CSR projects outsourced by various industries, ISR activities administered through Technological Association approved by the Dean, Student Affairs.

SEMESTER -V										
Subject Code	Subject	Course Type	Credits	Hrs/Week			Marks for various Exams			
				L	T	P	CA	MS	ES	Total
CET1806	Chemical Reaction Engineering	PCC	2	1	1	0	20	30	50	100
CET1807	Chemical Engineering Operations	PCC	2	1	1	0	20	30	50	100
DYT1071	**SPL-7**: Technology of Non-ionic Dyes - I	PCC	4	3	1	0	20	30	50	100
XXXXXXX	**DSCT Elective - I** Offered by Department **(SPL-8)**	PEC-1	4	3	1	0	20	30	50	100
XXXXXXX	From Basic Sciences (Chemistry/ Physics/ Biology / Maths) or Humanities Discipline	OE	2	1	1	0	20	30	50	100
XXXXXXX	**MDM-III**	MDM	4	2	0	4	50	0	50	100
DYP1141	**Pr-4**: Lab 4: Analysis of Colorants and Fibers	PCC	2	0	0	4	50	0	50	100
DYP1151	**Pr-5**: Lab5: Preparation of Ionic Dyes	PCC	2	0	0	4	50	0	50	100
DYT1091	**Honors Course-I: Metal Complex Colorants**	PCC	4	3	1	0	20	30	50	100
	Total		**26**	**14**	**6**	**12**	-	-	-	900

SEMESTER –VI										
Subject Code	Subject	Course Type	Credits	Hrs/Week			Marks for various Exams			
				L	T	P	CA	MS	ES	Total
DYT1109	**SPL-9**: Technology of Ionic Dyes – II	PCC	3	2	1	0	20	30	50	100
DYT1111	**SPL-10**: Structural Elucidation of Dyes	PCC	3	2	1	0	20	30	50	100

XXXXXX	**DSCT Elective- II** Offered by Department **(SPL-11)**	PEC-2	4	3	1	0	20	30	50	100
DYT1131	**SPL-12**: Technology of Non-ionic Dyes - II	PCC	4	3	1	0	20	30	50	100
XXXXXX	**MDM-IV**	MDM	2	1	1	0	20	30	50	100
CEP1714	Chemical Engineering Laboratory	VSEC	2	0	0	4	50	0	50	100
DYP1161	**Pr-6**: Lab-6: Preparation of Non-ionic Dyes	PCC	2	0	0	4	50	0	50	100
DYP1171	**Pr- 7**: Lab -7: Application of Colorants	PEC	2	0	0	4	50	0	50	100
DYT1141	**Honors Course-II: Near-IR Absorbing Dyes – Chemistry and Technology**	PCC	4	3	1	0	20	30	50	100
	Total		**26**	**14**	**6**	**12**	-	-	-	900

SEMESTER –VII										
Subject Code	Subject	Course Type	Credits	Hrs/Week			Marks for various Exams			
				L	T	P	CA	MS	ES	Total
DYT1151	**SPL-13**: High Performance Pigments	PCC	3	2	1	0	20	30	50	100
DYT1161	**SPL-14**: Chemistry and Technology of Fluorescent Colorants	PCC	2	1	1	0	20	30	50	100
XXXXXX	**DSCT Elective - III** Offered by Department	PEC-3	3	2	1	0	20	30	50	100
XXXXXX	**DSCT Elective - IV** Offered by Department	PEC-4	2	2	0	0	20	30	50	100
XXXXXX	**MDM-V**	MDM	2	1	1	0	20	30	50	100
DYP1181	Literature Review (Research Methodology - I)	RM-1	2	1	0	2	50	0	50	100
DYT1201	Design and Analysis of Experiments (Research Methodology - II)	RM-2	2	1	0	2	20	30	50	100
DYP1191	Project-I (Literature search + Experiment)	Project	4	0	0	8	50	0	50	100
DYP1201	**Pr-8**: Lab-8: Synthesis, Analysis and Applications of Optical Brighteners	PCC	2	0	0	4	50	0	50	100
DYT1191	**Honors Course-III: Case Studies in Colorants Industry**	PCC	4	3	1	0	20	30	50	100
	Total		**26**	**13**	**5**	**16**	-	-	-	1000

SEMESTER -VIII (10 Weeks)					
Subject Code	Subject	Course Type	Credits	Hrs/Week	Marks for various Exams

				L	T	P	CA	MS	ES	Total
DYT1211	**SPL-15**: Applications of Organic Colorants	PCC	3	5	1	0	20	30	50	100
XXXXXX	**MDM-VI**	MDM	2	2	1	0	20	30	50	100
DYP1211	Project-II (Experiments)	PCC	3	0	0	16	50	0	50	100
DYP1221	**Pr-9**: Lab-9: Formulation and Functional Applications of Colorants	PEC	2	0	0	4	50	0	50	100
DYT1221	**Honors Course-IV: Formulation Technology in Colorants**	PCC	3	5	1	0	20	30	50	100
DYT1231	**Honors Course-V: Industrial Waste Management in Colorants Industry**	PCC	3	5	1	0	20	30	50	100
SEMESTER – VIII (12-16 Weeks)										
DYP1231	Internship with Industry (12 – 16 Weeks)	Internship/ On Job Training Project	12	0	0	0	50	0	50	100
	Total		**28**	**17**	**4**	**20**	-	-	-	700

BSC: Basic Science Course,
ESC: Engineering Science Course
PCC: Program Core Course, **PEC**: Program Elective Course
MDM: Multi-disciplinary Minor: Different discipline of engineering or different faculty altogether
OE: Open Elective: To be chosen compulsorily from faculty other than major discipline
VSEC: Vocational and Skill Enhancement Course: Hands on training corresponding to major/minor
AEC: Ability Enhancement Course: English 2 credit, Modern Indian Language 2 credit
IKS: Indian Knowledge System: Indian Architecture/Maths/Medicine
VEC: Value Education Course: e.g. Understanding India, Environmental Science/Education/Digital and Tech solutions
RM: Research Methodology
CCA: Co-curricular activities: Health and wellness / Yoga / Sports / Cultural activities / NSS/NCC/Applied visual performing arts
EEM: Entrepreneurship / Economics / Management

D.Detailed Syllabus

FIRST YEAR: SEMESTER-I

BSC	**Course Code: CHT1405**	**Course Title: Physical Chemistry**	**Credits = 3**		
			L	**T**	**P**
	Semester: I	**Total contact hours: 45**	**2**	**1**	**0**
List of Prerequisite Courses					
Standard XII Chemistry					
List of Courses where this course will be prerequisite					
Physical and Analytical Chemistry laboratory (CHP1343), Transport Phenomena (CET1105)					
Description of relevance of this course in the B. Tech. Program					

The course will enable the students to understand and apply the principles of thermodynamics to real-world systems. The students would be able to apply the insights to understand the stability of solutions, spontaneity of physical/chemical processes, effect of thermodynamics parameters on phase and chemical equilibria,		
Course Contents (Topics and subtopics)		**Required Hours**
Sr. No	**Course Contents (Topics and Subtopics)**	**6**
1	**Laws of thermodynamics** – a) Enthalpy and heat capacities, application of first law to gases, thermochemistry- Hess law b) Statements and applications of second law of thermodynamics, Clausius inequality, entropy as a state function, entropy changes for reversible and irreversible processes, entropy and probability c) Third law of thermodynamics, absolute entropies, verification of third law	**3**
2	**Spontaneous process and equilibrium** –Helmholtz and Gibbs free energy, spontaneity and free energy, Maxwell's relations, effect of T and P on free energy,	**6**
3	**Multicomponent system –** free energy and entropy of mixing, partial molar quantities and chemical potential, Gibbs Duhem equation	**7**
4	**Equilibrium in solutions –** ideal and non-ideal solutions, Henry's law and Raoult's law, colligative properties, activity and activity coefficients, thermodynamic properties of electrolytes in solution	**5**
5	**Solubility equilibria** – solubility constant, common ion effect, effect of added salts on solubility pH, weak and strong acids and bases, buffer solutions, ionic solutions **Chemical Equilibria –** le Chaterlier's principle, Effect of temperature, pressure and composition on equilibrium	**3**
6	**Introduction** – concept of reaction rates and order, experimental methods in kinetic studies, differential and integral methods to formulate rate equations of zero, first and second order reactions Experimental methods of kinetic studies	**6**
7	**Kinetics and reaction mechanism** – rate determining step, steady state approximation **Complex reactions**- parallel, consecutive and reversible reactions Mechanism of thermal, photochemical chain reactions, polymerization reactions **Fast reactions –** experimental techniques	**6**
8	**Homogenous catalysis** – homogeneous acid / base catalysis (specific and general acid catalysis), enzyme catalysis (Michelis Menten kinetics)	**3**
9	**Reactions at interface –** Adsorption isotherms, kinetics of surface reactions- Hishelwood and Rideal models of surface reactions	
	Total	**45**
List of Textbooks/ Reference Books		
1	Atkins, Peter W.; Paula, Julio de; Keeler, James. Atkin's Physical Chemistry; 11th ed.; Oxford University Press (2018).	
2	Elements of Physical Chemistry (7th edition) by P. W. Atkins and J. de Paula, Oxford University Press, 2016.	
3	Chemical Kinetics (3rd edition) by Keith J. Laidler, New York : Harper & -Row, 1987.	
Course Outcomes (students will be able to….)		
CO1	Understand the concepts of thermodynamics and relate them to measurable quantities	K2
CO2	Elucidate the effect of thermodynamic quantities on physical and chemical equilibria	K4
CO3	Correlate the thermodynamic properties of chemical systems with the observed outcomes and predict the optimum conditions	K3
CO4	Comprehend fundamental knowledge in chemical kinetics with basics of order, molecularity and temperature effect	K2
CO5	Examine kinetics for complex, fast and interfacial reactions	K3

CO6	Comprehend different theories in kinetics to explain the molecular origin of kinetic phenomena	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	3	2	1	2	0	0	1	0	2
CO2	2	3	2	3	2	2	2	1	1	1	1	1
CO3	2	3	2	3	2	2	2	1	1	1	1	1
CO4	2	3	1	2	2	1	2	0	0	1	0	2
CO5	3	3	2	3	2	2	2	1	0	1	0	1
CO6	2	2	3	3	2	1	1	1	0	1	1	1

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	1	1
CO2	2	1	1	1	0
CO3	2	2	2	1	1
CO4	2	2	2	1	1
CO5	2	1	2	0	0
CO6	2	1	1	1	1

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

BSC	**Course Code: CHT1406**	**Course Title: Analytical Chemistry**	**Credits = 3**		
			L	**T**	**P**
	Semester: I	**Total contact hours: 45**	**2**	**1**	**0**

List of Prerequisite Courses

Standard XII Chemistry

List of Courses where this course will be prerequisite

Physical and Analytical Chemistry Laboratory(CHP1343), Structural Elucidation of Dyes (DYT1111)

Description of relevance of this course in the B. Tech. Program

The course introduces the students to key concepts of chemical analysis – sampling, selection of analytical method and data analysis. It presents basic techniques like spectroscopy and chromatography. The students should be able to select an appropriate analytical technique and apply it in accordance with its strengths and limitations.

Course Contents (Topics and subtopics)		**Required Hours**
1	Introduction to chemical analysis, terminology (technique/method/procedure/ protocol), broad classification of analytical techniques, good laboratory practices	5
2	Criteria for selecting analytical methods – accuracy, precision, sensitivity, selectivity, and detection limit Calibration and validation	8
3	**Data analysis**: errors – systematic and random errors, statistical treatment of experimental results (F, Q and t tests, rejection of data, and confidence intervals), least square method, correlation coefficients	6
4	**Spectroscopic methods**: General principle, instrumentation and applications of • UV-visible spectroscopy • Infrared spectroscopy • fluorescence spectroscopy	8
5	**Electrochemical methods:** General principle, instrumentation and applications of	8

	• Conductometry • Potentiometry	
6	**Chromatographic methods:** General principle, instrumentation and applications of • Gas chromatography (GC) • HPLC	10
	Total	**45**

List of Textbooks/ Reference Books	
1	David Harvey. Modern Analytical Chemistry; McGraw-Hill (1999)
2	R. A. Day and A. L. Underwood. Quantitative Analysis, Prentice Hall of India (2001)
3	H. H. Willard, L. L. Merritt, J. A. Dean and F. A. Settle. Instrumental Methods of Analysis, 7th ed.; Wadsworth Publishing, USA (2004)
4	D. A. Skoog, D. M. West, F. James Holler and S. R. Crouch. Fundamentals of Analytical Chemistry; 9th ed.; Cengage Learning (2013)
5	D. A. Skoog, F. James Holler and S. R. Crouch. Principles of Instrumental Analysis; 6th ed.; Cengage Learning (2016)

Course Outcomes (students will be able to….)		
CO1	Explain the principles of UV-visible and fluorescence spectroscopic methods	K3
CO2	Explain the principles of electrochemical methods	K3
CO3	Understand the principles of chromatographic separations	K3
CO4	Evaluate the results of chemical analysis in terms of accuracy and precision	K4
CO5	Apply the principles of sampling to design an optimum analytical protocol	K4
CO6	Identify conditions to minimize the error and increase the sensitivity of analysis	K5
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	2	2	1	1	0	1
CO2	2	3	2	3	3	2	2	1	1	1	0	1
CO3	2	3	2	3	3	2	2	0	1	1	0	1
CO4	2	3	2	3	3	2	2	1	1	1	0	1
CO5	2	2	2	1	2	1	1	1	0	1	1	0
CO6	2	2	1	1	2	1	2	1	0	0	0	0

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	1	1	1
CO2	1	2	1	2	1
CO3	2	2	2	1	2
CO4	1	2	1	2	1
CO5	1	2	1	1	1
CO6	1	2	1	1	1

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

ESC	**Course Code: MAT1301**	**Course Title: Engineering Mathematics**	**Credits = 3**		
			L	**T**	**P**
	Semester: I	**Total contact hours: 45**	**2**	**1**	**0**
List of Prerequisite Courses					

XII Standard Mathematics		
List of Courses where this course will be prerequisite		
Chemical Engineering Laboratory (CEP1714), Process Calculations (CEP1720), Design and Analysis of Experiments (Research Methodology – II, DYT1201)		
Description of relevance of this course in the B. Tech. Program		
This is a basic Mathematics course which will give the students the required foundations of mathematics to understand engineering/technology concepts in the later part of the technology programs. This course will also introduce probability distributions and basic statistics will be helpful to understand various data science studies in different technology disciplines.		
Course Contents (Topics and subtopics)		**Required Hours**
1	**Linear Algebra:** Vectors in $\mathbb{R}^n$, notion of linear independence and dependence. $\mathbb{R}^n$ as a vector space, vector subspaces of $\mathbb{R}^n$, basis of a vector subspace, row space, null space, and column space, rank of a matrix. Determinants and rank of matrices. Linear transformations in $\mathbb{R}^n$, Matrix of a linear transformation, change of basis and similarity, rank-nullity theorem, and its applications. Inner product spaces, orthonormal bases, Gram-Schmidt orthogonalization process, Eigenvalues and eigenvectors, characteristic polynomials, eigenvalues of special Orthogonal projection and its application to least square methods, Diagonalization of matrices and its applications to stochastic matrices	15
2	**Differential Calculus:** Higher order differentiation and Leibnitz Rule for the derivative, Taylor's and Maclaurin's theorems, Maxima/Minima, convexity of functions and applications. Functions of two or more variables, Limit and continuity, Partial differentiation, Total derivatives, Taylor's theorem for multivariable functions and its application to error calculations, Maxima/Minima, Method of Lagrange Multipliers, Introduction to double and triple integrals.	15
3	**Probability & Statistics:** Random variables and cumulative distribution function; probability mass function and probability density function; Some common univariate distributions: Binomial, Poisson, Uniform, exponential, Normal; Expectation and Moments; Moment generating function, Multiple random variables, and Joint distribution; marginal distributions, Covariance and Correlation. Concept of parameter estimation: maximum likelihood estimation; method of least squares and simple linear regression; nonlinear regression	15
	Total	**45**
List of Textbooks/ Reference Books		
1	G. Strang, Linear Algebra and its Applications (4th Edition), Thomson (2006).	
2	Howard Anton, Elementary Linear Algebra, John Wiley & Sons (2016)	
3	Stewart, James, Single Variable Calculus, 6th Edition, Cenage learning (2016)	
4	Hughes-Hallett et al., Calculus - Single and Multivariable (3rd Edition), John-Wiley and Sons (2003).	
5	E. Kreyszig, Advanced Engineering Mathematics (8th Edition), John Wiley (1999). (Officially prescribed)	
6	S. R. K. Iyengar, R. K. Jain, Advanced Engineering Mathematics Narosa, (2020)	
7	A First Course in Probability, Sheldon Ross, Pearson Prentice Hall, 9th Edition (2018)	
8	W.W. Hines, D. C. Montgomery, D.M. Goldsman, John-Wiely, Probability and Statistics in Engineering, John Wiley & Sons (2008)	
9	Alexander M. Mood, Duane C. Boes, and Franklin A. Graybill, Introduction to the Theory of Statistics, Mc GrawHill, (1973)	
Course Outcomes (students will be able to….)		
CO1	Understand the notion of differentiability and be able to find maxima and minima of functions of one and several variables.	K3

CO2	Understand the notion of integrability and be able to compute multiple integrals and apply them in engineering applications.	K3
CO3	Understand the computational and geometrical concepts related to linear transformations, eigenvalues and eigenvectors and apply them to solve computational problems	K3
CO4	Demonstrate understanding of different concepts in linear algebra in solving computational problems related to vectors and matrices and apply them to solve problems arising the technology especially in AI and ML.	K4
CO5	Understand the concepts of various probability distributions and apply them to analyze various technology problems and make inference about the system	K3
CO6	Understand the method of linear and nonlinear least squares method and apply it to choose appropriate mathematical functions for modelling real data sets, arising from technology disciplines	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	0	0	0	0	0	0	3
CO2	2	2	1	1	1	0	0	0	0	0	0	3
CO3	2	2	1	1	1	0	0	0	0	0	0	3
CO4	2	2	1	1	2	0	0	0	0	1	0	3
CO5	2	2	1	1	1	0	0	0	0	0	0	3
CO6	2	3	3	1	2	1	0	0	3	1	0	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	1	1	1	0
CO2	2	1	1	2	0
CO3	1	0	2	1	0
CO4	2	1	1	2	0
CO5	1	0	1	1	0
CO6	2	1	1	2	0

BSC	**Course Code: PYT1205**	**Course Title: Applied Physics**	**Credits = 2**		
			L	**T**	**P**
	Semester: I	**Total contact hours: 30**	**1**	**1**	**0**

List of Prerequisite Courses

Standard XII Science

List of Courses where this course will be prerequisite

Project-II (DYP1211), Transport Phenomena (CET1105)

Description of relevance of this course in the B. Tech. Program

Materials and their properties play a key role in chemical technology. The Applied Physics course will provide the students with the necessary fundamentals to develop a broad understanding of various aspects related to materials, thereby equipping them with the ability to apply it wherever required in their course of study.

Course Contents (Topics and subtopics)		**Required Hours**
1	Crystal Structure of Solids: A revision of concepts of a lattice, a basis, a unit cell, different crystal systems (SC, BCC, FCC, HCP), co-ordination numbers and packing fractions. Single crystalline, Polycrystalline, and Amorphous materials.	3

2	Crystallographic planes and directions: concept of Miller indices and its determination, examples; calculation of inter-planar spacing in terms of Miller indices.	3
3	Determination of crystal structure using X-rays: Bragg's law of X-ray diffraction, types of diffractometers, Indexing diffraction peaks, and calculation of various lattice parameters and crystallite size	4
4	Energy band in solids and classification of solids, the concept of Fermi level and Fermi distribution function, Intrinsic and extrinsic semiconductors, Transport properties of semiconductors: Conductivity in semiconductors and its dependence of carrier concentration and mobility	5
	Physics of Fluids	
5	A revision of the basic concepts of hydrostatics and ideal fluid flow: Equation of continuity and Bernoulli's equation.	4
6	The concept of viscosity, Newton's law of viscosity, Reynold's number, Poiseuille's equation for streamline flows	4
7	An introduction to Rheology: Parameters of viscous flows, Newtonian and non-Newtonian behaviour, Variation of viscosity with shear rate, shear time, temperature, and pressure (qualitative ideas with illustrative examples), measuring properties of viscous flows. The concept of viscoelasticity, Maxwell and Kelvin models of relaxation, relaxation spectrum, creep testing.	7
	Total	**30**

List of Textbooks/ Reference Books	
1	Fundamentals of Physics - Halliday, Resnick, Walker - 6th Edition - John Wiley
2	Sears and Zeemansky's University Physics - Young and Freedman - 12th Edition - Pearson Education
3	A Textbook of Engineering Physics - M N Avadhanulu, P G Kshirsagar, TVS Arun Murthy - 11th Edition - S. Chand Publishers
4	Solid State Physics - S. O. Pillai - 10th Edition - New Age Publishers
5	Solid State Physics - A. J. Dekker - MacMillan India
6	Engineering Physics - V Rajendran - 6th Edition - McGraw Hill Publishers
7	Introduction to Rheology – H. A. Barnes, J. F. Hutton and K. Walters – 4th Edition – Elsevier Science.
8	Viscoelastic Properties of Polymers – J. D. Ferry – 3 rd Edition – Wiley
9	

Course Outcomes (students will be able to….)		
CO1	Assign Miller indices to various crystallographic planes and directions in a crystal lattice, thereby understanding periodicity in the crystal lattice.	K4
CO2	Analyze a given x-ray diffraction pattern to deduce the material's crystal structure and calculate the values of the basic structural parameters.	K4
CO3	Classify solids, and in turn semiconductors, based on electron occupancy and calculate basic quantities related to charge transport in them.	K3
CO4	Analyze simple ideal fluid flows by applying the continuity equation and Bernoulli's equation	K3
CO5	Describe the basic behavior of viscous flows and the relationships between various flow parameters.	K4
CO6	Understand simple models that are used to describe viscoelastic flows.	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	2	1	1	1	1	1	1	3
CO2	3	3	3	2	2	1	1	1	1	1	1	3

CO3	3	3	2	2	2	2	1	1	1	1	1	3
CO4	3	2	3	3	2	1	1	1	1	1	1	3
CO5	2	2	2	3	2	1	1	2	1	1	1	3
CO6	2	2	3	2	2	1	1	1	1	1	1	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	1	0
CO2	2	2	2	2	0
CO3	3	3	2	1	0
CO4	2	3	3	2	0
CO5	3	2	2	1	0
CO6	3	2	2	2	0

VSEC	**Course Code:** GEP1129	**Course Title:** Engineering Drawing and Computer Aided Drafting	**Credits = 3**		
			L	**T**	**P**
	Semester: I	**Total contact hours: 75**	**1**	**0**	**4**

List of Prerequisite Courses

Standard XII Mathematics

List of Courses where this course will be prerequisite

Project-I (DYP1191) and Project-II (DYP1211), Professional Career (Industrial drawing, Equipment Design, Manufacturing and designing of any component, industrial 3D product modelling etc.)

Description of relevance of this course in the B. Tech. Program

Drawing is a language used by technologists. A student is required to know the various equipments used to carry out the processes. Some of the elementary areas like product sizing, manufacturing etc., are very common to all the branches of technology. These and many other processes require machines and equipment's. One should be familiar with the design, manufacturing, working, maintenance of such machines and equipment's. The subject of "drawing" is a medium through which one can learn all such matters, because the "drawings" are used to represent objects and various processes on paper. Through the drawings, a lot of accurate information is conveyed which will not be practicable through a spoken word or a written text. This course is required in many subjects as well as later in the professional career.

Course Contents (Topics and subtopics)		**Required Hours**
1	**Orthographic projections:** Introduction, Principles of Projection, Methods of Projection, Planes of projection, Quadrants, First-angle method of projection, Third-angle method of projection, and concept of orthographic projections.	15 (3L+12P)
2	**Sectional Projections and Missing Views:** Need for the drawing sectional views, concept of sectioning and section lines, Sectional drawings of different solids and machine components, Auxiliary planes, and views. **Missing Views**: Concept of recognizing missing views and their interpretation, drawing of missing views from given orthographic drawings.	15 (3L+12P)
3	**Isometric projections:** Concept of isometric views, isometric projections and isometric scale, Iso metric projections of different solids and machine components.	10 (2L+8P)
4	**Computer Aided Drafting and Assembly drawing:** Basic introduction to CAD softwares, Design and Development of new products, Application of CAD, 2D, 3D part modelling on softwares, drawing modification and dimensioning, modelling of different machine components. Basics of	10 (2L+8P)

	Assembly drawing, preparation of 2D, 3D components and assembling on CAD software, conversions, labelling and table creation for bill of materials.	
1	**Orthographic projections:** Introduction, Principles of Projection, Methods of Projection, Planes of projection, Quadrants, First-angle method of projection, Third-angle method of projection, and concept of orthographic projections.	25 (5L+20P)
	Total	**75 (15L+60P)**
List of Textbooks/ Reference Books		
1	Engineering Drawing by N.D.Bhat, CHAROTAR publishing house, Anand, Gujrat, 51th Edition.	
2	Engineering Drawing by N.H.Dubey, Nandu Printers & Publishers Pvt. Ltd, 15th Edition.	
3	CAD/CAM: Theory and Practice by Ibrahim Zeid and R Sivasubramanian, McGraw Hill Education, 2nd Edition.	
Course Outcomes (students will be able to….)		
CO1	Draw Orthographic Projections of Solid objects.	K4+P2
CO2	Draw Third view of solid object when two views are given	K4+P2
CO3	Draw isometric Projections of Solid objects.	K4+P2
CO4	Draw assembly of various machine components	K4+P2
CO5	Understand basic commands of CAD software	K2+P2
CO6	Use CAD software for drafting and editing 2 dimensional drawings	K3+P2
K1-Remembering, K2-Understanding, K3-Applying, K4-Analyzing, K5-Evaluating, K6- Creating P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	0	0	0	0	0	0	0	1	0	0	0
CO2	3	0	0	0	0	0	0	0	1	0	0	0
CO3	3	0	0	0	0	0	0	0	1	0	0	0
CO4	3	0	0	0	0	0	0	0	1	0	0	0
CO5	3	0	0	0	3	0	0	0	2	0	0	0
CO6	3	0	0	0	3	0	0	0	2	0	0	0

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	1	1	1	0
CO2	1	0	1	1	0
CO3	2	0	1	2	0
CO4	1	1	1	1	0
CO5	1	0	1	1	0
CO6	2	0	1	1	0

ESC	**Course Code:** **DYT1011**	**Course Title:** **SPL1: A Primer on Technology of Intermediates and Dyestuffs**	**Credits = 2**		
			L	**T**	**P**
	Semester: I	**Total Contact Hours: 30**	**1**	**1**	**0**
List of Prerequisite Courses					
HSC (Science)					
List of Courses where this course will be prerequisite					
All dyestuff courses					

Description of relevance of this course in the B. Tech. Program		
To make the students understand chemistry of various intermediates used in chemical and dyestuff industry To make them understand the unit processes and their relevance in chemical industries To enable them to analyses and identify the proper synthetic and industrial method and choose accordingly the further processes to make intermediates To develop in them a capacity to understand proper selection of the chemical processes based on economy and ecological aspects		
	Course Contents (Topics and Subtopics)	**Required Hours**
1	Chemical feedstock for Dyestuff industry- Basic Raw materials **a.** Fossil feedstock **b.** Petroleum and coal based raw materials **c.** Importance of BTX	05
2	Chemistry of Benzenoid intermediates- **a.** Electrophilic aromatic substitution reaction **b.** Orientation in aromatic substitutions	05
3	Introduction of Functional groups into benzene and technology involved **A.** Basic Unit processes a. Sulphonation b. Nitration c. Reduction d. Halogenation **B.Sulphonation:** (i) Reaction phenomenon and conditions (ii) Sulphonating agents and solvents (iii) Work up and Material of construction (iv) **Substitution in benzene and substituted benzene** (v) Plant and process flow (vi) Safety and process control parameters **C. Nitration:** (i) Reaction phenomenon and conditions (ii) Nitrating agents and solvents (iii) Work up and Material of construction (iv) Substitution in benzene and substituted benzene (v) Plant and process flow (vi) Safety and process control parameters, Run away reactions **D. Reduction:** (i) Reducing agents (ii) Reduction methods (iii) Selection of best method for Benzene and substituent (iv) Process and workup (v) Safety aspect **E. Halogenation** (i) Basic nucleophilic and Electrophilic substitution (ii) Reaction and MOC	05
4	Naphthalene Introduction a. Nomenclature, Reactions, Reactivity rules	05
5	Chemistry: Naphthalene intermediates **a.** Synthesis of naphthalene **b.** Substitution pattern **c.** Reactions possible and criterion for the same	05
6	Technology and Reactions of naphthalene	05

	a. Nitration **b.** Sulphonation **c.** Halogenation **d.** Reduction (Key points are similar to benzene)	
	Total	**30**
List of Textbooks/Reference Books		
1	Industrial organic chemistry, Weissermal K., ArpeH.J.VCH, Weinheim, 1993	
2	Organic synthesis, Smith M B, Tata McGrow Hill, NY, 2nd Ed, 2004	
3	Chemistry of Synthetic Dyes, Lubs H. A., NY 1995	
4	Chemistry of synthetic dyes vol I, Venkatraman K., NY 1952	
5	Organic Chemistry,Clayden, Oxford Univ. Press, 2001	
Course Outcomes (Students will be able to…..)		

CO1	*Understand* the basics of dyestuff industry in terms of raw materials utilized	K2
CO2	*Apprehend* basic benzene and naphthalene chemistry	K2
CO3	*Analyze* the various methods for synthesis of different intermediates used in dyes	K2
CO4	*Know* the various technology and safety aspects for reactions	K2
CO5	*Identify* the substrates and chemistry to synthesize desired product	K2
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	0	1	0	0	0	0	2	0
CO2	2	2	1	1	0	1	0	0	0	0	2	0
CO3	2	3	3	3	0	1	0	0	0	0	2	0
CO4	3	2	3	3	0	3	2	0	0	0	2	0
CO5	2	3	2	3	0	2	2	0	0	0	2	0

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	0
CO2	2	2	2	2	1
CO3	2	2	2	2	2
CO4	2	2	2	2	1
CO5	2	2	2	2	1

AEC	**Course Code: HUP1110B**	**Course Title: Communication Skills**	**Credits = 2**		
			L	**T**	**P**
	Semester: I	**Total contact hours: 60**	**0**	**0**	**4**
List of Prerequisite Courses					
Standard XIIth English					
List of Courses where this course will be prerequisite					
All courses in this and subsequent semesters					
Description of relevance of this course in the B. Tech. Program					
This is an important course for the effective functioning of an Engineer and a Technologist. Communication skills are required in all courses and professional career.					
Course Contents (Topics and subtopics)			**Required Hours**		
1	Communication as a way of life		6		

	Process of communication and its elements Functions of communication and importance in future careers Essentials of good communication	
2	The communication cycle The 5 step communication cycle: Idea formation Message encoding Message transmission Decoding Feedback	4
3	Factors affecting effective communication Planning for effective communication Modes of communication	3
4	Non verbal communication Gestures Facial expressions Posture and movement Paralinguistics Eye contact Image management	4
5	Presentation skills What makes good presentation Prsenting the message Presenting oneself Visual Communication	8
6	Introduction to research study Introduction to databases Introduction to citation and referencing styles How to conduct literature review Preparation of a report based on literature review	5
	Total	**60**
List of Textbooks/ Reference Books		
1	Elements of Style – Strunk and White	
Course Outcomes (students will be able to….)		
CO1	Student would be able to illustrate the 5 step communication process	K2+P2
CO2	Student would be able to explain the end goal of communication	K2+P2
CO3	Student would be able to explain barriers to clear communication	K2+P2
CO4	Student would be able to articulate the role of visual communication within society, and implement the creative process to express himself/herself.	K2+P2
CO5	Student would be able to identify the most relevant textbooks, reviews, papers and journals	K2+P2
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	0	0	0	0	0	0	1	1	3	3	2	3
CO2	0	0	0	0	0	0	1	1	3	3	2	3
CO3	0	0	0	0	0	0	1	1	3	3	2	3
CO4	0	0	0	0	0	0	1	1	3	3	2	3
CO5	0	0	0	0	0	0	1	1	3	3	2	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	0	0	0	0	0
CO2	0	0	0	0	0
CO3	0	0	0	0	0
CO4	0	0	0	0	0
CO5	0	0	0	0	0

CCA	**Course Code: XXXXXXX**	**Course Title: Yoga and Self Development**	**Credits=2**		
			L	**T**	**P**
	Semester: I	**Total contact hours: 60**	0	0	4

Prerequisites

It may be necessary to gather some basic information about the students, such as their age, marital status, academic schedules, and recreational activities, whether they have any sleep issues and stress because of any situation. It shall be better to know how the students deal with stress, and whether they have proper nutrition. We also might need information about any injuries past or current and any other medical condition that may interfere in the program.

List of Courses where this course will be prerequisite

Applicable throughout professional and personal lives

Description of relevance of this course in the B. Tech. Program

Yoga is not course but a journey. The benefits of Yoga are many. It brings in calmness of mind besides the physical fitness by doing Yoga Aasanas. Apart from flexibility developed by regular physical activities, it makes one aware of his own potential. Professional and personal lives are full of situations that can be stressful. Yoga helps the students to withstand the stress coming from the expectations and demands of their own lives.

Sr. No	Course Contents (Topics and subtopics)	Reqd. hours
1	**Yoga** The principles and foundations of yoga. Both concentrative and insight meditation techniques may be practiced for each session. Behavioural techniques of self-monitoring should also be practiced observing the stream of consciousness from the perspective of a vigilant but detached observer. The students shall be trained to practice different models of mindfulness and meditation so as to elicit a state of deep physical and behavioural relaxation. They may work on selectively influencing or changing the symmetry in hemispheric brain activity. Positive addiction, meta-cognitive practices etc. are exercised to make the students experience the universal human capacity through spiritual experiences. The students may learn to turn-off or bypass the cognitive processing of usual daily preoccupations and concerns, allowing access to mindful, spiritual and meditative state of self-realization The students shall keep a small journal to write down their own journey/progress on physical flexibility, strength building and most importantly, how they deal with stressful conditions. This record will form the paper assessment of the student. Yoga helps to develop many mental skills like mindfulness, self-control, focus, and even self-compassion. It's mainly a physical practice. The students are taken through different movements and poses during the yoga sessions.	40

2	**Assessment: The** following assessments are recommended: Regular attendance **Paper Assessment**: A paper assessment may include assessing student's understanding of the basic philosophy of yoga Verbal Assessment on the basis of his/her ability to assimilate the philosophy of yoga and practicing in daily life. Mobility & Flexibility assessment is to assess the strength and flexibility, like twist.	20
	List of Books	
1	Yoga Sutra of Patanjali, Ramakrishna Mission, Kolkata	
2	RN Jha, Science of Consciousness Psychotherapy and Yoga Practices, Vidyanidhi Prakashan, Delhi 2016	
Course Outcomes (students will be able to…..)		
CO1	Keep physically fit and mentally agile	K2
CO2	Manage stress in studies and later in life	K2
CO3	Coordinate body and mind together	K2
CO4	Understand own emotions and maintain healthy daily routine	K2
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	0	1	2	0	1	0	1	2	2	1	0	2
CO2	0	1	2	0	1	0	1	2	2	1	0	2
CO3	0	1	2	0	1	0	1	2	2	1	0	2
CO4	0	1	2	0	1	0	1	2	2	1	0	2

Course Code:	**Course Title: Fine Arts and Performing Arts**	**Credits = 2**		
		L	**T**	**P**
Semester: I	**Total contact hours: 30**	**0**	**0**	**4**

List of Prerequisite Courses

No

List of Courses where this course will be prerequisite

NA

Description of relevance of this course in the B. Tech. Program

Cultivation of arts is an integral part of the development of human beings since the arts are what make us most human, most complete as people. They offer us the experience of wholeness because they touch us at the deepest levels of mind and personality. They come into being not when we move beyond necessity but when we move to a deeper necessity, to the deeper human need to create order, beauty and meaning out of chaos. They are the expressions of deepest human urges, imperatives and aspirations

	Course Contents (Topics and subtopics)	**Reqd. hours**
1	The Institute offers a range of courses in different art forms: music, dance, theatre, painting, and other art forms. Students will be given an option to choose a particular art form, and learn and practice it under an artist-instructor. At the end of the course, a student should be able to demonstrate basic proficiency in that particular art form.	30
	Total	**30**

Course Outcomes (students will be able to…..)		
CO1	Enhance perceptual and cognitive skills	
CO2	Develop self-esteem, motivation, aesthetic awareness, cultural exposure	
CO3	Be creative with improved emotional expression	
CO4	Develop social harmony and appreciation of diversity.	
CO5	Develop an understanding and sharing of culture, with social skills that enhance the awareness and respect of others	
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	0	0	1	0	2	1	1	2	2	2	1	2
CO2	0	0	1	0	2	1	1	2	2	2	1	2
CO3	0	0	1	0	2	1	1	2	2	2	1	2
CO4	0	0	2	0	1	1	1	2	2	1	1	2
CO5	0	0	2	0	1	1	1	2	2	1	1	2

BSC	**Course Code: PYP1101**	**Course Title: Physics Laboratory**	**Credits = 2**		
			L	**T**	**P**
	Semester: I	**Total contact hours: 60**	**0**	**0**	**4**

List of Prerequisite Courses

XII Physics

List of Courses where this course will be prerequisite

Project-II (DYP1211)

Description of relevance of this course in the B. Tech. Program

The hands-on experience gained by the students in the Applied Physics laboratory course will equip them with basic experimental skills related to measurement of various important physical quantities. These skills will act as a useful foundation for other laboratory and theory courses in their area of specializations.

	Course Contents (Topics and subtopics)	Required Hours
1	Determination of Co-efficient of Viscosity by Poiseuille's method	4
2	Thermistor characteristics: Determination of Bandgap of a semiconductor	4
3	Determination of compressibility of liquids using an Ultrasonic Interferometer	4
4	Measurement of thermal conductivity of a solid: Lee's disc method	4
5	Photoelectric effect: Determination of h/e	4
6	Hall effect-I (sample current variation) Determination of carrier type and concentration in a semiconductor	4
7	Hall effect-II (magnetic field variation) Determination of carrier type and concentration in a semiconductor	4
8	Newton's rings: Determination of wavelength of light	4
9	Laser Diffraction: Determination of particle size	4
10	Studying variation of compressibility of liquid as function of temperature	4
11	Estimating resistivity of semiconductor using four probe method	4
12	Determination of magnetic susceptibility of paramagnetic liquid using Quincke's method	4
	Total	**60**

List of Textbooks/ Reference Books	
1	Fundamentals of Physics - Halliday, Resnick, Walker - 6th Edition - John Wiley
2	Sears and Zeemansky's University Physics - Young and Freedman - Pearson Education
3	Engineering Physics - V Rajendran - 6th Edition - McGraw Hill Publishers
4	Fundamentals of Optics - F. Jenkins and H. White - 4th Edition McGraw Hill
5	ICT Physics Laboratory Manual (supplied to students)

Course Outcomes (students will be able to….)		
CO1	Independently set up, handle, and use basic setups to measure and obtain various physical quantities.	K4+P2
CO2	Use basic instruments like vernier-caliper, screw-gauge, travelling microscope, thermometer, etc. to make accurate measurements.	K4+P2
CO3	Correlate and use directly measured quantities to obtain the relevant parameters through appropriate formulae, calculations, and/or graphical plotting, thereby understand the measurement principle involved in the experimental setups.	K3+P2
CO4	Preliminarily treat the obtained datasets statistically to obtain errors in the experiments.	K4+P2

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	1	1	2	1	1	1	3	1	1	0
CO2	2	3	1	1	2	1	1	1	3	1	1	0
CO3	2	3	1	1	2	1	1	1	1	1	1	0
CO4	2	3	1	1	2	1	1	1	1	1	1	0

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	2	1
CO2	3	3	3	1	1
CO3	3	1	2	2	0
CO4	2	2	3	1	1

SEMESTER-II

BSC	Course Code: CHT1407	Course Title: Organic Chemistry	Credits = 3		
			L	T	P
	Semester: II	Total contact hours: 45	2	1	0

List of Prerequisite Courses

Standard XII Chemistry

List of Courses where this course will be prerequisite

Pharmaceutical Chemistry, Medicinal Chemistry, Biochemistry and several Special Subjects of Chemical Technology Departments

Description of relevance of this course in the B. Tech. Program

To acquaint the students with IUPAC and other types of Nomenclature of organic compounds, fundamentals of Organic Chemistry including reaction mechanisms, organic transformations, types of reactions, selectivity of chemical transformations, etc., stereochemical implications of organic reactions, functional group identification and reactions

Course Contents (Topics and subtopics)		Required Hours
1	**Chemistry of Carbonyl Compounds** Concept of acidity and tautomerism of carbonyl compounds, General methods of preparation and Nucleophilic Addition reactions Enolate chemistry, Aldol and related condensation reactions, Michael reaction, Robinson annulation, Claisen condensation, Dieckmann condensation, Mannich reaction.	**9**
2	**Aromatic Substitution Reactions** **A) Electrophilic Substitution Reactions** Nitration, Halogenation, Alkylation, Acylation and Sulfonation Activating, deactivating and orienting effects of functional groups in mono- and poly-substituted benzenes Friedel-Crafts alkylation, Acylation, Gattermann, Gattermann-Koch, Riemer-Tiemann reactions. **B) Nucleophilic Substitution Reactions:** Addition and elimination mechanism, Benzyne mechanism, Sandmeyer reaction.	**10**
3	**Heteroaromatic Compounds** IUPAC nomenclature, structures and common names, comparison with benzenoid compounds, reactivity and synthesis – pyrroles, furans, thiophenes and pyridines	**8**
4	**Named Organic Reactions** Perkin reaction (Mauvine synthesis-dyes), Fischer indole synthesis, (dyes), Jacobson Corey epoxide synthesis (Pharmaceutical), Ziegler Natta polymerisation (polymer), Multicomponent reactions, Mailard reaction (foods), Strecker amino acid synthesis (Pharmaceuticals & Food), Wittig reactions, Prilezhaev reaction	**10**
5	**Stereochemistry of Organic Compounds** Containing one and two asymmetric carbon atoms, Stereo descriptors – R/S, E/Z, erythro and thero, Conformation – Ethane and butane. Enantiomers and Diastereomers, meso compounds, different representations of stereoisomers – Saw-horse, Newmann, Wedge and dash and Fischer and their interconversions	**8**
	Total	**45**
List of Textbooks/ Reference Books		
1	Clayden, J., Greeves, N., Warren, S.; Organic Chemsitry; 2nd ed.; Oxford University Press (2012)	
2	Graham Solomons, T. W.; Fryhle, Craig B.; Snyder, Scott A. Organic Chemistry; 12th Ed.; John Wiley & Sons. Inc. (2016)	
3	Smith, M. B.; March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure; 7th ed.; Wiley, India (2015)	
4	Carey F. A., Sundberg, R. J. Advanced Organic Chemistry: Part A: Structure and Mechanisms; 5th ed.; Springer (2005)	
5	Carey F. A., Sundberg, R. J.; Advanced Organic Chemistry: Part B: Reaction and Synthesis; 5th ed.; Springer (2007)	
6	Wade, L. G.; Simek, J. W.; Singh, M. S. Organic Chemistry; 9th ed.; Pearson Education (2019)	
7	Eliel, E. L. Stereochemistry of Carbon Compounds; Mcgraw-Hill (2001)	
8	Bruice, Paula, Y. Organic Chemistry; 8th Ed.; Pearson Education (2020)	
Course Outcomes (students will be able to….)		
CO1	Draw structures of organic compounds and write their IUPAC names correctly	K2
CO2	Understand principles of aromatic chemistry and interpret the outcome of general transformations	K3
CO3	Understand the importance of heterocycles, learn the properties and synthetic routes, interpret the IUPAC of compounds and decipher outcomes of various transformations involving heterocycles	K3

CO	Apply the knowledge obtained through the course to predict the outcome of reactions and devise solutions to unknown problems	K4
CO5	Appreciate the stereo-chemical implications of organic compounds and visualize and appreciate the chirality concept	K4
CO6	Understand organic chemistry reactions related to aliphatic as well as aromatic compounds as well as decipher the outcome of a given organic transformation	K4
CO7	Interpret and analyze reactions having different functionalities, deduce and solve problems related to the reactions as well as apply them	K5
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	1	1	0	2	1	0	2	0	2
CO2	2	2	2	2	2	1	3	1	1	1	0	2
CO3	1	2	2	1	1	1	3	2	0	1	1	2
CO4	3	3	2	3	2	1	2	1	0	2	1	1
CO5	2	3	3	1	2	1	3	1	0	1	0	1
CO6	2	3	2	1	1	2	2	0	1	1	0	1
CO7	2	3	3	3	2	2	2	2	1	1	1	1

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	3	2
CO2	2	1	3	2	1
CO3	2	2	2	2	1
CO4	3	3	3	3	1
CO5	3	2	2	2	1
CO6	3	3	3	3	1
CO7	3	3	3	3	1

BSC	**Course Code: CHT1408**	**Course Title: Industrial Chemistry**	**Credits = 3**		
			L	**T**	**P**
	Semester: II	**Total contact hours: 45**	**2**	**1**	**0**

List of Prerequisite Courses	
Standard XII Chemistry	

List of Courses where this course will be prerequisite

Industrial Waste Management in Colorants Industry (DYT1231)

Description of relevance of this course in the B. Tech. Program

It is important for technology graduates to be familiar with the industrial scale-up of basic organic and inorganic reactions. The course aims to acquaint the students with synthesis, properties and applications of various industrial inorganic chemicals of commercial importance. The economic and ecological factors to be considered while selection and execution of such processes will also be discussed.

Course Contents (Topics and subtopics)		**Required Hours**
1	**Introduction to Chemical Industry**: Bulk chemicals, fine chemicals, intermediates, active pharmaceutical ingredients (API), etc.	**3**
2	**Petrochemical Industry**: operations and processes in manufacture of ethers, hydrocarbons, aromatic compounds, etc.	**6**
3	**PRIMARY INORGANIC MATERIALS**: Water, Hydrogen, Hydrogen Peroxide and Inorganic Peroxo Compounds, Nitrogen and Nitrogen Compounds, Phosphorus	**8**

	and its Compounds, Sulfur and Sulfur Compounds, Halogens and Halogen Compounds,	
4	**MINERAL FERTILIZERS**: Phosphorus-Containing Fertilizers, Nitrogen-Containing Fertilizers, Potassium-Containing Fertilizers	**4**
5	**METALS AND THEIR COMPOUNDS**: Alkali and Alkaline Earth Metals and their Compounds Aluminum and its Compounds, Chromium Compounds and Chromium, Silicon and its Inorganic Compounds, Manganese Compounds and Manganese	8
6	**ORGANIC BULK CHEMICALS**: Manufacture of methanol, acetic acid, ethanol, ethylene, propylene, butadiene, acetaldehyde, acetylene, BTX, alkyl benzenes, acetone, phenol, styrene, esters, ethylene oxide, phthalic acid, Vinyl-Halogen and Vinyl-Oxygen Compounds, azo dyes, Polyamides, Propene Conversion Products, Aromatics - Production and Oxidation Products of Xylene and Naphthalene	**8**
7	Important pharmaceutically active ingredients, agrochemicals, insecticides, pesticides, perfumery chemicals.	**8**
	Total	**45**
List of Textbooks/ Reference Books		
1	Industrial Organic Chemistry, 3rd, Completely Revised Edition, Klaus Weissermel, Hans-Jürgen Arpe ISBN: 978-3-527-61459-2 July 2008.	
2	Industrial Inorganic Chemistry, 2nd Completely Revised Edition, Karl Heinz Buchel, Hans-Heinrich Moretto, Dietmar Werner, ISBN: 978-3-527-61333-5, 667 pages, November 2008, Wiley-VCH.	
3	Inorganic Chemistry – an industrial and environmental perspective, T.W. Swaddle, ISBN 0-12- 678550-3 , 482 pages, Academic Press	
Course Outcomes (students will be able to….)		
CO1	Understand the important chemical principles applied to various industrial processes	K2
CO2	Describe the fundamental processes underlying manufacture of important organic chemicals	K2
CO3	Describe the fundamental processes underlying manufacture of important inorganic chemicals	K2
CO4	Review and assess the impact of the chemical factors on the efficiency of industries and feedstock manufacturing	K3
CO5	Modify existing applications for improving the efficiencies in terms of yields, energy requirement and environmental impact	K4
CO6	Evaluate the modifications in terms of long-term environmental implications	K5
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	1	3	1	1	3	0	2
CO2	3	2	3	2	2	2	3	1	2	2	1	2
CO3	3	3	3	2	1	2	3	2	2	2	2	2
CO4	3	3	3	2	1	3	3	2	2	2	2	2
CO5	2	1	3	1	1	2	2	1	1	1	0	0
CO6	2	2	1	1	1	1	2	1	1	1	0	0

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	2	1	1
CO2	2	2	2	2	2

CO3	2	2	2	2	2
CO4	1	1	1	0	1
CO5	1	2	2	1	1
CO6	2	2	2	2	2

PCC	Course Code: DYT1021	COURSE TITLE: SPL2: Physical and Chemical Constitution of Colorants	Credits = 2		
			L	T	P
	Semester: II	Total Contact Hours: 30	1	1	0

List of Prerequisite Courses

HSC (Science); SPL1: A Primer on Technology of Intermediates and Dyestuffs (DYT1011)

List of Courses where this course will be prerequisite

All dyestuff courses

Description of relevance of this course in the B. Tech. Program

Students will be able to understand the relation between the chemical structure and the colour.

	Course Contents (Topics and Subtopics)	Required Hours
1	Origin of colour in organic molecules. Chromatic and achromatic colors. Red shift, blue shift, hyperchromic effect, solvatochromism, halochromism. Beer-Lambert's law, absorptivity, oscillator strength, , and half band width.	02
2	Early theories of color and constitution - empirical correlations between the chemical structures and their color. Chromophores, auxochromes, distribution rules, chromogens. n→π*, donor-acceptor, acyclic and cyclic polyene, and cyanine type chromogens	02
3	Resonance theory of color, failures of resonance theory. Steric effects in electronic absorption spectra – some general considerations.	02
4	Perturbational molecular orbital theory: Alternation of the electronegativity of an atom in an even alternant system. Alteration of the electronegativity of an atom in an odd alternate system, Dewar rules. Other empirical approaches to substituent effects, Mesomeric and field effects, Correlation between the frequency shift of a substitution and the Hammett substituent constant	02
5	Simple donor-acceptor chromogens: general characteristics – donor group, unsaturated bridge, acceptor group. The carbonyl acceptor – merocyanine types of compounds.	02
6	Complex donor-acceptor chromogens: classes of complex acceptor residues, donor substituted quinones. Donor substituted azo compounds. Color and constitution of simple azo dyes. Steric effects, and azo-hydrazonetautomerism in azo dyes	02
7	Color and chemical constitution of indigoid dyes. Introduction to cross-conjugated chromophores. Chromogens based on acycyclicand cyclic polyene systems: general characteristics with examples. Cyanine type chromogens.	02
8	Di- and triaryl methane colorants, heterocyclic analogues of di- and triaryl methane colorants. Simple color and constitution relationships.	02
9	Essentials of computational colour chemistry – brief introduction to one particle system. Schrodinger equation. Particle in a box.	02
10	Two particle system, Many particle systems – HartreeFock theory. Basis sets.	02
11	Electronic Structure theory. Molecular orbitals and light absorption. Semiempirical methods,	02
12	Limitations of HartreeFock method, Computational complexities in post HartreeFock (wavefunction based methods).	02
13	Introduction to Density Functional Theory and its application in colour chemistry	02
14	Excited State calculations, Configuration Interaction Singles.	02
15	Time Dependent Density Functional Theory.	02

	Total	**30**
List of Textbooks/Reference Books		
1	Chemistry of Synthetic Dyes and Pigments, Lubs H. A., Robert E Krieger Publishing Company, New York, 1977	
2	Chemistry of Synthetic Dyes – Vol I, Venkataraman, K., Academic Press, 1952	
3	Chemistry of Synthetic Dyes – Vol III, Venkataraman, K., Academic Press, 1972	
4	Colour and Chemical Constitution of Organic Dyes, Griffiths J., Academic Press, 1976	
5	Quantum Chemistry, Chandra A. K., Tata McGraw Hill, 1979	
Course Outcomes (Students will be able to…..)		
CO1	*Understand* the constitution of different colorants	K2
CO2	*Analysis* the correlation of proposed absorption and observed absorption	K2
CO3	*Identify* the colour changes with different classes of molecules	K2
CO4	*Understand* the detail properties of colour changes with respective structural changes	K2
CO5	*Assess* the technical importance of colour chemistry	K2
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	0	0	0	0	0	0	3	0
CO2	2	2	2	2	1	0	0	0	0	0	3	0
CO3	2	2	2	2	1	1	1	1	1	1	3	1
CO4	3	3	3	3	1	2	2	2	2	2	3	1
CO5	2	2	2	2	1	2	2	2	2	2	3	1

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	1
CO2	3	2	2	2	1
CO3	2	2	2	2	1
CO4	2	1	2	2	1
CO5	2	2	2	2	2

ESC	**Course Code:** **GET1306**	**Course Title:** **Basic Mechanical Engineering**	**Credits = 2**		
			L	**T**	**P**
	Semester: II	**Total Contact Hours: 30**	**1**	**1**	**0**
List of Prerequisite Courses					
Applied Physics (PYT1205), Engineering Mathematics(MAT1301)					
List of Courses where this course will be prerequisite					
Professional Career					
Description of relevance of this course in the B. Tech. Program					
Students will be able to understand various equipment's like steam turbine, gas turbine, pumps, compressors, and power transmission system.					
Course Contents (Topics and subtopics)			**Required Hours**		
	Introduction- Concept of Stress • Condition of Equilibrium for concurrent coplanar and non-concurrent coplanar forces.		6		

	• Deformation in solids- Hooke's law, stress and strain- tension, compression and shear stresses, Stress-Strain diagrams, elastic constants and their relations volumetric, linear and shear strains.	
	Introduction to Thermodynamics • First Law of Thermodynamics, • Steady-flow energy equation, Second Law of Thermodynamics	4
	Basics of Power Station • **Steam Generators:** Fire tube and Water tube boiler, Low pressure, and high-pressure boilers, Mountings and accessories, Boiler efficiency. • **Steam Turbines:** Working principle of steam, gas and water turbines, Concept of impulse and reaction steam turbines. • **Compressors and Pumps:** Types of Compressors and their applications, Different Types of Pumps, and their applications	8
	Transmission of Power • Introduction to various drives such as belt, rope, chain and gear drives, • Introduction to mechanical elements such as keys, couplings, and bearings in power transmission.	4
	Refrigeration and Air-conditioning • Vapour compression refrigeration cycle, Vapour absorption refrigeration systems. • Properties of air such as DBT, WBT, DPT, relative humidity, Psychometric chart.	4
	Renewable Energy • Role and importance of non-conventional and alternate energy sources such as solar, wind, ocean, bio-mass and geothermal, hydrogen energy.	4
	Total	**30**

List of Textbooks/ Reference Books	
1	Strength of Materials by S. Ramamrutham, Dhanpat Rai Pvt. Ltd
2	Thermodynamics by P.K. Nag
3	Power plant by Morse
4	Heat Engines by P.L. Balani
5	Hydraulic Machines by Jagdish Lal
6	Renewable Energy resources by Tiwari and ghosal, Narosa publication.
7	Non-conventional energy sources, Khanna publications
8	Refrigeration and air conditioning by C.P. Arora
9	Theory of Machines by Rattan. S.S
10	Gas turbine theory by HiH Saravanamutoo.

Course Outcomes (students will be able to….)		
CO1	Understand different types of stresses and their effects on bodies.	K2
CO2	Understand and apply the physics of laws of thermodynamics and mass-balancing.	K3
CO3	Analyze the working of steam boilers, boiler mountings, and accessories, gas turbines, types of pumps, types of compressors and its working process.	K4
CO4	Discuss different types of power transmission systems and their typical applications.	K5

CO5	Understand the working principle of vapor compression and vapor absorption refrigeration systems.	K2
CO6	Understand the importance of non-conventional energy sources as an alternative source of fuels.	K2
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	2	2	0	0	0	0	0	2
CO2	2	2	2	0	2	2	2	0	0	0	0	2
CO3	3	3	2	1	1	2	2	2	0	0	0	2
CO4	3	3	1	2	1	1	2	0	0	0	0	2
CO5	2	1	2	1	1	2	1	3	0	0	0	2
CO6	2	0	0	0	0	1	3	2	0	0	0	2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	0	0
CO2	1	2	2	2	0
CO3	1	1	2	0	0
CO4	1	2	1	3	0
CO5	2	2	2	0	0
CO6	1	2	2	2	0

ESC	**Course Code:** GET1125	**Course Title:** Electrical Engineering and Electronics	**Credits = 2**		
			L	**T**	**P**
	Semester: II	**Total Contact Hours: 30**	**1**	**1**	**0**

List of Prerequisite Courses

XII Science, Applied Physics (PYT1101), Engineering Mathematics (MAT1301)

List of Courses where this course will be prerequisite

Colorants in Organic Electronics (DYT1171)

Description of relevance of this course in the B. Tech. Program

Students will get an insight to the importance of Electrical Energy in Chemical Plants. The students will understand the basics of electricity, selection of different types of drives for a given application process. They will get basic knowledge as regards to Power supplies, instrumentation amplifiers and thyristor application in industries.

	Course Contents (Topics and subtopics)	**Required Hours**
1	**Fundamentals of DC Circuits** Voltage and Current Sources, Basic Laws, Network Theorems, Superposition Theorem and Thevenin's Theorem,	4
2	**AC Fundamentals:** A.C. through resistance, inductance and capacitance, simple RL, RC and RLC circuits. Power, power factor	4
3	**Three Phase Systems**: Three phase system of emfs and currents, Star and Delta connections, three phase power	3
4	**Single phase transformers**: Principle of working, Efficiency, regulation.	3
5	**Electrical drives**: Basic concepts of different types of Electrical motors as drives, Their suitability for various applications.	2

6	**Regulated power supplies**, Diodes as rectifiers, Half wave and Full wave rectifier, Filters and Regulators	3
7	**Bipolar junction transistors**: Different configurations, Characteristics, Concept of basic amplifier circuits, Amplifier gain, Transistor as switch	3
8	**Introduction to Integrated circuits:** Basic concepts of ICs	2
9	**Introduction to data acquisition and signal conditioning,** Basic concept and Block diagram, Concept of conversion of physical quantity to electrical signal, signal conditioning, Introduction to A/D and D/A converters	3
10	**Introduction to instrumentation amplifiers and their applications** Operational Amplifier – Notation, Pin diagram, Differential and common mode gain, CMRR, Introduction to various applications such as Non-inverting, inverting amplifiers, adder,subtractor, integrator, differentiator,	3
	Total	**30**
List of Textbooks/ Reference Books		
1	Electrical Engineering Fundamentals by Vincent Deltoro	
2	Electronic devices and circuits by Boylstead, Nashelsky	
3	Electrical Machines by Nagrath, Kothari	
4	Electrical Technology by B.L.Theraja, A.K.Theraja vol I,II,IV	
Course Outcomes (students will be able to….)		
CO1	Understand the basic concepts of D.C. supply and circuits, Solve basic electrical circuit problems	K3
CO2	Understand the basic concepts single phase and three phase AC supply and circuits, Solve basic electrical circuit problems	K3
CO3	Understand the basic concepts of transformers, evaluate, and calculate efficiency at various load condition.	K5
CO4	Understand the concept of motors and their uses as various industrial drives.	K5
CO5	Understand the basic concepts of electronic devices and their applications in power supplies, amplification and instrumentation	K4
CO6	Understand the basic concepts of operational amplifiers and their applications, Understand the concept of Data acquisition, signal conditioning	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	0	0	0	0	0	2	3	2	0	0
CO2	3	3	0	0	0	0	0	2	3	2	0	0
CO3	3	3	0	0	0	0	0	2	3	2	0	0
CO4	3	3	0	0	0	0	0	2	3	2	0	0
CO5	3	3	0	0	0	0	0	2	3	2	0	0
CO6	3	3	0	0	0	0	0	2	3	2	0	0

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	1	1	0
CO2	2	1	2	0	0
CO3	2	1	2	0	0
CO4	2	1	1	0	0
CO5	2	1	2	0	0
CO6	2	1	2	0	0

ESC	Course Code: CEP1720	Course Title: Process Calculations	Credits = 2		
			L	T	P
	Semester: II	Total contact hours: 60	0	0	4

List of Prerequisite Courses

Standard XIIth Mathematics, Chemistry, Applied Physics(PYT1205)

List of Courses where this course will be prerequisite

Project-II (DYP1211)

Description of relevance of this course in the B. Tech. Program

This is a basic course. This knowledge will be required in almost all subjects later. This subject introduces the various concepts used in Chemical Engineering to the students. The knowledge of this subject is required for in All B. Tech. courses, etc. It can be applied in various situations such as process selection, economics, sustainability, environmental impacts

	Course Contents (Topics and subtopics)	Required Hours
1	Introduction to Chemical process calculations, overview of single stage and multistage operations, concept of process flow sheets	2
2	Revision of Units and Dimensions, Dimensional analysis of equations, Mathematical techniques	4
3	Mole concept, composition relationship, types of flow rates	2
4	Material balance in non-reacting systems: application to single and multistage processes	8
5	Stoichiometry	2
6	Material balance in reacting systems: application to single and multistage processes	6
7	Behavior of gases and vapors	4
8	Introduction to psychrometry, humidity and air-conditioning calculations.	6
9	Calculation of X-Y diagrams based on Raoult's law.	2
10	Applications of material balances to Multiphase systems	6
11	Basic concepts of types of Energy and calculations	2
12	Application of Energy balance to non-reacting systems	6
13	Application of Energy balance to reacting systems	6
14	Fuels and combustion.	4
	Total	**60**

List of Textbooks/ Reference Books

1	Elementary Principles of Chemical Processes, Felder, R.M. and Rousseau,
2	Chemical Process Principles, Hougen O.A., Watson K. M.
3	Basic Principles and Calculations in Chemical Engineering, Himmelblau,
4	Stoichiometry, Bhatt B.I. and Vora S.M.

Course Outcomes (students will be able to….)

CO1	Students should be able to calculate friction factor, pressure drop, power requirements of singe phase flow in a circular pipe	K2+P2
CO2	Students will be able to select appropriate pump based on flow and head requirements	K3+P2
CO3	Students should be able to calculate heat transfer coefficients and do basic sizing of double pipe and shell and tube heat exchangers	K3+P2
CO4	Students should be able to perform preliminary sizing of phase change equipment such as reboilers and condensers	K3+P2
CO5	Students should be able to calculate mass transfer coefficients and estimate mass transfer rates in simple situations	K3+P2
CO6	Students should be able to understand empirical correlations and solve various equations analytically or numerically	K4+P2

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	1	1	1	1	1	1	3
CO2	3	3	2	3	2	1	2	1	1	1	1	3
CO3	3	3	3	3	3	1	2	2	2	1	1	3
CO4	3	3	3	3	3	1	1	1	2	1	1	3
CO5	3	3	2	3	2	1	1	1	1	1	1	3
CO6	3	3	2	3	3	1	1	1	1	1	1	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	1	2	1
CO2	3	2	1	3	1
CO3	3	3	2	3	1
CO4	3	3	2	3	2
CO5	3	2	1	3	1
CO6	2	2	1	2	1

CCA	**Course Code:**	**Course Title:** Physical Activities (Sports & games)	Credits = 2		
			L	**T**	**P**
	Semester: II	**Total contact hours: 60**	0	**0**	4

List of Prerequisite Courses

None

List of Courses where this course will be prerequisite

Not Applicable

Description of relevance of this course in the B. Tech. Program

Games and sports are necessary and useful for all. Games play an important part in life. Education is incomplete without games. Games are necessary to keep the body fit and trim. Moreover, they provide recreation. As a result, one feels smart and cheerful throughout the day. If one is cheerful and healthy, he or she is able to get the best out of life. A player really enjoys life. For him, life is a song and a beauty. Games teach us the lesson of discipline, team-work, patience and punctuality. In the playground, the players obey the captain and abide by the rules of the games. Games also teach us that we should play a game for game's sake, not for victory or defeat. A healthy man is always hopeful and cheerful.

	Course Contents (Topics and subtopics)	**Reqd. hours**
1	The students shall select participating a specific sports/game/physical activity of their choice in morning/evening or at other suitable times according to the local climate. This would involve a routine of physical activity with games and sports. Physical activity means any bodily movement produced by skeletal muscles requiring energy expenditure, for example, Walking, gardening, climbing the stairs, playing soccer. Activities can be considered vigorous, moderate, or light in intensity. Activity makes one breathe harder and one's heart beat faster. **Moderate physical activities** include: • Walking briskly (about 3½ miles per hour) • Bicycling (less than 10 miles per hour)	60

	• General gardening (raking, trimming shrubs) • Dancing • Golf (walking and carrying clubs) • Water aerobics • Canoeing • Tennis (doubles) **Vigorous physical activities** include: • Running/jogging (5 miles per hour) • Walking very fast (4½ miles per hour) • Bicycling (more than 10 miles per hour) • Heavy yard work, such as chopping wood • Swimming (freestyle laps) • Aerobics • Basketball (competitive) • Tennis (singles)	
Course Outcomes (students will be able to…..)		
CO1	Keep physically fit and mentally agile	K2
CO2	Manage stress in studies and later in life	K2
CO3	Coordinate body and mind together	K2
CO4	Understand own emotions and maintain healthy daily routine	K2
CO5	Develop team work and an ability to work with others for a common goal	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	0	1	0	0	0	1	1	1	1	1	0	1
CO2	0	1	0	0	0	1	1	1	1	1	0	1
CO3	0	1	0	0	0	1	1	1	1	1	0	1
CO4	0	1	0	0	0	1	1	1	1	1	0	1
CO5	0	1	0	0	0	1	1	1	1	1	0	1

IKS	**Course Code: HUT1117**	**Course Title: Traditional Indian Chemical Technology**	**Credits = 2**		
			L	**T**	**P**
	Semester: II	**Total Contact Hours: 30**	**2**	**0**	**0**
List of Prerequisite Courses					
NIL					
List of Courses where this course will be prerequisite					
NIL					
Description of relevance of this course in the B. Tech. Program					
To acquaint the students with major chronological developments in Indian science and technology.· To review the ancient discoveries and research related to chemicals in Pharmaceuticals, flavours and fragrances, metallurgy, architecture, textile, agriculture and Ayurveda etc. To know the fundamental principles of Indian health systems such as Ayurveda, which is useful in maintaining well-being. To facilitate the students to identify and develop interest in the ancient knowledge systems to make meaningful contributions to the development of science today. To develop respect and pride about Indigenous Knowledge thereby to assist the learners' understanding about conclusions/products from ancient Indian knowledge system for verifying them on modern scientific and technological footings.											
Course Contents (Topics and subtopics)					**Required Hours**						

1	**Introduction to Indian Knowledge System (IKS):** - Introduction, Definition and History - Need to study it in current times Chemists and texts of the ancient era	2
2	**Traditional Indian Pharmaceutical Sciences and Technology:** Alternative systems of Medicine/ Welfare of the society: Principles of Ayurveda - Medicinal plants and crude drugs - Reappraisal of Ayurvedic Phytochemistry - Ayurvedic Dosage forms and similarity to that of modern dosage forms - Extraction of herbs in Ayurvedic System and comparison to that of modern extraction process - Detoxification of poisonous plants (*Shodhan Prakriya*) Ancient perspective of Adulterants and Substitutes	6
3	**Traditional Indian Knowledge on Oils, Perfumery and Flavoring agents** - Essential oils and fixed oils Applications in perfumery and flavoring-fragrance industry	3
4	**Traditional Indian Knowledge on Textile and Fibres** - Types of fibers - Textile patterns across the country Methods and Techniques	2
5	**Traditional Indian Knowledge on Dyes, Pigments, mordents and specialty chemicals** - Natural dyes and pigments Sources, Methods of dying	2
6	**Traditional Indian Knowledge on Polymers and surface coatings** Waxes, Gums, Carbohydrates	2
7	**Traditional Indian Food Technology**	2
8	Traditional Indian Knowledge about Metallurgy and Materials Science	3
9	**Traditional Indian Preservation Technology** - Methods of preservation: Food, monuments and artifacts Materials used in Preservation	3
10	Science associated with traditional Indian practices during festivals	2
11	Connecting The traditional Indian Knowledge with Modern Science	3
	Total	**60**

List of Textbooks/ Reference Books

1	Acharya Prafulla Chandra Ray, A History of Hindu Chemistry, 1902, republ., Shaibya Prakashan Bibhag, centenary edition, Kolkata, 2002
2	B. Mahadevan and Vinayak Rajat Bhat, INTRODUCTION TO INDIAN KNOWLEDGE SYSTEM: CONCEPTS AND APPLICATIONS, **PHI Learning publication, 2022**
3	The Positive Sciences of the Ancient Hindus; Brijendra Nath Seal; 4th Edition; 2016
4	Fine Arts & Technical Sciences in Ancient India with special reference to Someśvara's Mānasollāsa; Dr. Shiv Shekhar Mishra, Krishnadas Academy, Varanasi 1982
5	A Concise History of Science in India, ed. D M Bose, S N Sen and B V Subbarayappa; INSA; 2009
6	Science and Technology in Medieval India - A Bibliography of Source Materials in Sanskrit, Arabic and Persian by A Rahman, M A Alvi, S A Khan Ghori and K V Samba Murthy; 1982.
7	Vaidya Navnitlal B. Pandya, Fundamental principles of ayurveda part – 1. October 1982 Ancient Science of Life.
8	Vasant Lad, Textbook of Ayurveda: Fundamental Principle, reprint 2010
9	Lakshmi chandra Mishra (Editor), Scientific Basis for Ayurvedic Therapies, CRC Press LLC 2003
10	H.Panda, **Handbook on Speciality Gums, Adhesives , Oils, Rosin & Derivatives, Resins, Oleoresins, Katha, Chemicals with other Natural Products,** Asia Pacific Business Press Inc., 2022
11	Achyut Godbole, Anna, Madhushree Publication, 2022, Marathi edition
12	BHOJANAKUTUHALAM, RAGHUNATHA SURI (Author), FRLHT (Contributor), DR.M.A.ALWAR (Editor), DR.PADMA VENKAT, THE MEDPLAN CONSERVATORY SOCIETY 2019

13	R.M. Pujari, Pradeep Kolhe, N. R. Kumar, 'Pride of India: A Glimpse into India's Scientific Heritage', Samskrita Bharati Publication.
14	'Indian Contribution to science', compiled by Vijnana Bharati.
15	'Knowledge traditions and practices of India',Kapil Kapoor, Michel Danino, CBSE, India

Course Outcomes (students will be able to….)		
CO1	List the key achievements of Ancient India in different areas of Chemical Technology	K3
CO2	Describe the various features of traditional Indian knowledge in different areas of Chemical Technology	K2
CO3	Describe Key Principles of Traditional Indian Health Systems	K2
CO4	Describe the various products and key technology aspects based on traditional Indian Knowledge in context of Modern science	K2
CO5	Understanding the applications of IKS in current practices.	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	3	0	1	3	3	1	0
CO2	3	2	2	1	1	3	0	1	3	3	1	0
CO3	3	2	2	1	1	3	0	1	3	3	1	0
CO4	3	2	2	1	1	3	0	1	3	3	1	0
CO5	2	1	1	3	1	1	0	1	1	3	1	1

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	1	3	2
CO2	2	2	1	1	1
CO3	2	1	1	3	2
CO4	2	1	1	1	2
CO5	2	2	1	1	2

???	Course Code: XXXXXXX	Course Title: Universal Human Values-I	Credits = 2		
			L	T	P
	Semester: II	Total contact hours: 60	0	0	4

List of Prerequisite Courses

NA

List of Courses where this course will be prerequisite

NA

Description of relevance of this course in the B.Tech. Program

This **audit course with no extra ceridit** 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.

A module in Universal Human Values provides the base of character building. The objective of the course is four fold:

1. Sensitization of student towards self, family (relationship), society and nature.
2. Understanding (or developing clarity) of nature, society and larger systems, on the basis of human relationships and resolved individuals.
3. Strengthening of self-reflection.
4. Development of commitment and courage to act..
5. **The second year mark list, this course with result a s Pass/Fail with mandate hrs in place.**

Course Contents (Topics and subtopics)		Required Hours
1	Purpose and motivation for the course	60
2	Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and Experiential Validation- as the process for self-exploration 3. Continuous Happiness and Prosperity- A look at basic Human Aspirations	
3	Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority	
4	Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario	
5	Method to fulfil the above human aspirations: understanding and living in harmony at various levels.	
6	**Methodology of this Course:** Methodology of teaching this content must not be through do's and dont's, but get the 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. Include practice sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking	
	Total	**60**
List of Text Books		
1	Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010	
2	Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999	
3	The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi	
4	Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.	
Course Outcomes (students will be able to….)		
CO1	Become more aware of their surroundings, society, social problems and their sustainable solutions, while keeping human relationships and human nature in mind.	K2
CO2	Develop better critical ability.	K2
CO3	Become sensitive to their commitment towards what they believe in (humane values. humane relationships and humane society).	K3
CO4	Apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	0	1	0	0	0	1	1	1	1	1	0	1
CO2	0	1	0	0	0	1	1	1	1	1	0	1
CO3	0	1	0	0	0	1	1	1	1	1	0	1

CO4	0	1	0	0	0	1	1	1	1	1	0	1

BSC	Course Code: CHP1343	Course Title: Physical and Analytical Chemistry Laboratory	Credits = 2		
			L	T	P
	Semester: II	Total Contact Hours: 60	0	0	4

List of Prerequisite Courses

Standard XII Chemistry, Physical Chemistry (CHT1405) and Analytical Chemistry (CHT1406)

List of Courses where this course will be prerequisite

Project-II (DYP1211)

Description of relevance of this course in the B. Tech. Program

The laboratory course is mainly focused on imparting critical experimental skills in Physical and Analytical Chemistry to the undergraduate students. It is expected that they will not only become familiar with laboratory experimental skills but also planning of experiments and interpretation of experimental tasks. The course will help them to understand the relevance of chemical principles in real-life applications.

	Course Contents (Topics and subtopics)	Required Hours
1	The experiments will focus on the following key concepts / skills: **Physical Chemistry:** • determination of dissociation constants of a polybasic acid • determination of critical micelle concentration (CMC) of the given surfactant • study of kinetics of reaction – order of reaction, activation energy • study of weak and strong electrolytes • characterization of polymers using MW / viscosity determination **Analytical Chemistry:** • determination of water quality (hardness / BOD / COD) • determination of composition in a mixture of acids • verification of Beer-Lambert's law • quality analysis (determination of Vitamin C, for example)	4h / Practical
	Total	**60**

List of Textbooks/ Reference Books

1	Practical Physical Chemistry – B.Viswanthan and P.S. Raghavan, 2005
2	Practical Physical Chemistry – Alexander Findlay, 1954

Course Outcomes (students will be able to….)

CO1	perform quantitative analysis of samples to determine purity / composition	K3+P2
CO2	use common laboratory instruments with appropriate calibration and safety protocols	K3+P2
CO3	apply concepts of equilibria and kinetics to determine properties of molecules / processes	K4+P2
CO4	design experiments for acquiring physicochemical data and to interpret results for addressing specific queries / requirements	K4+P2
CO5	Evaluate the results in terms of accuracy and estimated precision	K4+P2
CO6	Identify the sources of errors and design steps to minimise the same	K5+P2

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	1	3	1	1	3	0	2
CO2	3	2	3	2	2	2	3	1	2	2	1	2

CO3	3	3	3	2	1	2	3	2	2	2	2	2
CO4	3	3	3	2	1	2	2	2	2	2	2	2
CO5	3	2	3	2	2	2	3	1	2	2	1	2
CO6	3	3	3	2	1	2	3	2	2	2	2	2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	3	2	2
CO2	1	2	2	2	2
CO3	2	2	3	1	2
CO4	1	2	3	2	2
CO5	1	2	3	2	2
CO6	1	2	2	2	2

VSEC	**Course Code:** **CHP1132**	**Course Title:** **Organic Chemistry Laboratory**	**Credits = 2**		
			L	**T**	**P**
	Semester: II	**Total Contact Hours: 60**	**0**	**0**	**4**

List of Prerequisite Courses

Standard XII Chemistry, Organic Chemistry (CHT1407)

List of Courses where this course will be prerequisite

Preparation of Intermediates (DYP1131), Preparation of Ionic Dyes (DYP1151)

Description of relevance of this course in the B. Tech. Program

Students are introduced to basics of organic separations and identification of organic compounds based on their physicochemical properties. The course is relevant for training the students for working with binary mixtures. The laboratory training is crucial for the students to carry out work-up of organic reactions leading to separation of crude products followed by purification using recrystallization and/or distillation or related methods.

Course Contents (Topics and subtopics)		**Required Hours**
1	a) Principles of qualitative separation of organic mixtures using physical properties, chemical properties and their combination b) Principles of quantitative separation of organic mixtures using physical properties, chemical properties and their combination	4h/Practical
2	a) Separation of solid-solid water insoluble binary organic mixtures b) Separation of solid-solid partly water soluble binary organic mixtures c) Separation of solid-solid mixtures by fractional crystallization d) Separation of liquid-liquid mixtures by distillation e) Separation of liquid-liquid mixtures by solvent extraction	
	Total	**60**

List of Textbooks/ Reference Books

1	Arthur, Vogel. Textbook of Practical Organic Chemistry, 5th edition, publishers Longman group Ltd, 1989
2	F.G. Mann and B.C. Saunders, Practical Organic Chemistry, 4th edition published by Orient Longman, 1974
3	Keese, R, Martin P. B, and Trevor P. Toube. Practical Organic Synthesis: A Student's Guide. John Wiley & Sons, 2006.

Course Outcomes (students will be able to….)

CO1	understand basic principles for separation of binary organic mixtures qualitatively and quantitatively	K3+P2

CO2	Estimate the components of binary mixtures quantitatively	K3+P2
CO3	separate binary organic mixtures by multiple techniques and test the purity	K3+P2
CO4	determine the purity of the individual components through quantitative analysis	K4+P2
CO5	Design experimental protocols to improve the purity of isolated components	K5+P2
CO6	Follow GLP protocols and work safely in the organic chemistry laboratory	K4+P2
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	2	1	1	2	1	1	2	2	1
CO2	2	2	2	3	1	1	2	1	1	2	2	2
CO3	1	2	3	3	1	2	2	2	1	1	1	2
CO4	2	2	3	2	1	2	2	3	3	3	2	2
CO5	3	3	3	2	1	2	3	2	2	2	2	2
CO6	3	3	3	2	1	2	2	2	2	2	2	2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	1	2
CO2	2	2	3	3	2
CO3	2	3	2	2	2
CO4	2	2	2	2	2
CO5	2	2	2	1	2
CO6	2	2	3	3	2

SECOND YEAR: SEMESTER – III

PCC	Course Code DYT1031	**Course Title:** **SPL3: Technology of Benzenoid Intermediates**	Credits = 4		
			L	T	P
	Semester - III	Total Contacts hours = 60	3	1	0
List of Prerequisite Courses					
HSC (Science); Organic Chemistry (CHT1407), SPL1: A Primer on Technology of Intermediates and Dyestuffs (DYT1011)					
List of Courses where this course will be prerequisite					
All Dyestuff courses; **Pr 3**: Lab-3: Preparation of Intermediates (DYP1131)					

Description of Relevance

To make the students understand chemistry various intermediates used for the chemical industry in general and the Dyestuff industry in particular

To make them understand the unit processes and their relevance in chemical industries.

To enable them to analyze and identify the proper synthetic and industrial methods and choose accordingly the further processes to make intermediates.

To develop in them capacity to understand proper selection of chemical processes based on economic and ecological aspects

		Hours
1	Chemistry of Benzenoid intermediates **a.** Electrophilic aromatic substitution reaction **b.** Orientation in aromatic substitutions	04
2	Introduction of Functional groups into benzene and technology involved. **A.** Basic Unit processes a. Sulphonation b. Nitration c. Reduction d. Halogenation **B. Sulphonation:** (i) Reaction phenomenon and conditions (ii) Sulphonating agents and solvents (iii) Work up and Material of construction (iv) **Substitution in benzene and substituted benzene** (v) Plant and process flow (vi) Safety and process control parameters **C. Nitration:** (i) Reaction phenomenon and conditions (ii) Nitrating agents and solvents (iii) Work up and Material of construction (iv) Substitution in benzene and substituted benzene (v) Plant and process flow (vi) Safety and process control parameters, Run away reactions **D. Reduction:** (i) Reducing agents (ii) Reduction methods (iii) Selection of best method for Benzene and substituent (iv) Process and workup (v) Safety aspect **E. Halogenation** (i) Basic nucleophilic and Electrophilic substitution (ii) Reaction and MOC	16
3	Unit Processes: a. Friedel Craft's Reaction b. Oxidation c. Ammonolysis d. Hydrolysis e. Diazotization and coupling	30
4	Active Methylene compounds	6
5	Technology and safety aspects	2
6	Separation techniques and agitation system	2
	Total	**60**

List of Textbooks/Reference Books	
1	Industrial organic chemistry, Weissermal K., ArpeH.J.VCH, Weinheim, 1993
2	Organic synthesis, Smith M B, Tata McGrow Hill, NY, 2nd Ed, 2004
3	Chemistry of Synthetic Dyes, Lubs H. A., NY 1995
4	Chemistry of synthetic dyes vol I, Venkatraman K., NY 1952
5	Organic Chemistry, Clayden, Oxford Univ. Press, 2001
Course Outcomes (Students will be able to…..)	

CO1	*Understand* the basics of Naphthalene chemistry	K2
CO2	*Conceptualize* basic unit processes for naphthalene and benzene	K2
CO3	*Analyze* the various methods for synthesis of different intermediates used in dyes	K2
CO4	*Master* the various technology and safety aspects for reactions	K2
CO5	*Know* various separation techniques used commercially and agitation systems for processes	K2
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	1	1	1	0	0	0	3	0
CO2	2	2	2	3	1	1	1	0	0	0	3	0
CO3	2	2	2	2	2	2	2	0	0	0	3	0
CO4	3	3	3	3	3	2	2	1	0	0	3	1
CO5	3	3	3	3	3	2	2	1	0	0	3	1

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	1
CO2	2	3	2	3	1
CO3	1	3	2	2	1
CO4	3	2	2	3	2
CO5	3	2	3	2	2

PCC	**Course Code: DYT1041**	**Course Title: SPL4: Quinonoid Intermediates - Chemistry and Technology**	**Credits = 2**		
			L	**T**	**P**
	Semester: III	**Total Contact Hours: 30**	**1**	**1**	**0**

List of Prerequisite Courses

SPL1: A Primer on Technology of Intermediates and Dyestuffs (DYT1011)

List of Courses where this course will be prerequisite

All dyestuff courses; **Pr 3**: Lab-3: Preparation of Intermediates (DYP1131)

Description of relevance of this course in the B. Tech. Program

The students will be introduced to the different chemical and technological aspects of accessing the intermediates of anthraquinone based dyes

	Course Contents (Topics and Subtopics)	**Required Hours**
1	Introduction to Anthraquinone chemistry, Synthesis, mechanism, sources of Anthraquinones	10
2	Synthesis of Anthraquinone and anthraquinone derivatives	10
3	Reactions of Anthraquinone: Sulphonation, Nitration, Halogenation, Bucherer Reaction	10
	Total	**30**

List of Textbooks/Reference Books

1	Industrial Organic Chemistry, Weissermal K., Arpe H. J., VCH, Weinheim, 1993
2	Organic Chemistry, Clayden, Greeves, Warren, Oxford University Press, 2001
3	FIAT 1313
4	Material of Construction, Lee
5	Unit Operations, McCabe, Smith
6	Chemistry of Synthetic Dyes – Vol I, Venkataraman, K., Academic Press, 1952
7	Synthesis and Application of Dyes, Rys and Zollinger
8	The Chemistry of Synthetic Dyes – Vol II, Venkataraman K., Academic Press
9	The Chemistry of Synthetic Dyes – Vol IV, Venkataraman K., Academic Press

10	The Chemistry of Synthetic Dyes – Vol VI, Venkataraman K., Academic Press
11	The Chemistry of Synthetic Dyes and Pigments, Lubs H. A., Robert E. Krieger Publishing Co
12	Industrial Dyes – Chemistry, Properties, Applications, Hunger K. (Ed), Wiley-VCH, Weinheim, 2003 ICT

Course Outcomes (Students will be able to…..)

CO1	*Define* and state different terminologies related to AQ	K2
CO2	*Describe* and explain the Chemistry and technology of AQ based compounds	K2
CO3	*Application* of AQ in pigments and dyes	K3
CO4	*Outline* the synthesis of various commercially important products	K2
CO5	*Develop* methods for the synthesis of quinonoid intermediates	K3

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	0	1	1	0	0	0	3	0
CO2	2	2	2	2	0	1	1	0	0	0	3	0
CO3	3	3	3	3	1	1	1	1	2	1	3	1
CO4	3	3	3	3	2	2	2	1	2	1	3	1
CO5	3	3	3	3	2	2	2	1	2	1	3	1

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	1
CO2	2	3	2	2	1
CO3	1	2	2	2	1
CO4	2	2	2	2	1
CO5	1	2	2	3	1

EEM	**Course Code: HUT1205**	**Course Title: Basic Economics and Finance**	**Credits = 2**		
			L	**T**	**P**
	Semester: III	**Total Contact Hours: 30**	**1**	**1**	**0**

List of Prerequisite Courses

NIL

List of Courses where this course will be prerequisite

Chemical Process Economics(CET1805), Project-II(DYP1211)

Description of relevance of this course in the B. Tech. Program

A Chemical Technology student will be experience the importance of Basic Economics and Finance in various industrial processes.

	Course Contents (Topics and subtopics)	**Required Hours**
1	**INTRODUCTION** Explaining the Economy The Supply and Demand Model Using the Supply and Demand Model	3
2	**THE COMPETITIVE EQUILIBRIUM MODEL** Deriving Demand Deriving Supply Market Equilibrium and Efficiency	5
3	**DEVIATIONS FROM COMPETITION** Monopoly and Market Power Between Monopoly and Competition Antitrust Policy and Regulation	5

4	MACRO FACTS AND MEASURES Getting Started with Macroeconomic Ideas Measuring Production, Income and Spending of Nations	5
5	**ACCOUNTING TRANSACTIONS** Journal entries Debit credit rules Compound journal entry Journal and ledger Rules of posting entries Trial balance	5
6	**CAPITAL AND REVENUE** Income and expenditure Expired costs and income Final accounts Manufacturing accounts Trading accounts Profit and Loss account Suspense account Balance sheet	5
7	CONCEPT OF DEPRECIATION	2
	Total	**30**

List of Textbooks/ Reference Books	
1	William G. Droms and Jay O. Wright Finance and Accounting for Nonfinancial Managers: All the Basics You Need to Know
2	E. Case Karl, C. Fair Ray, et al, PRINCIPLES OF ECONOMICS(12e)
3	A A Temu, D W Ndyetabula, et al Microeconomics: Basic Principles and Applications
4	Basic Finance for Nonfinancial Managers: A Guide to Finance and Accounting Principles for Nonfinancial Managers- Kendrick Fernandez
5	Microeconomic Theory: Basic Principles and Extensions- Walter Nicholson and Christopher Snyder
6	Macroeconomics(10e) Part of: Pearson Series in Economics (23 books) - by Froyen
7	William G. Droms and Jay O. Wright Finance and Accounting for Nonfinancial Managers: All the Basics You Need to Know

Course Outcomes (students will be able to….)		
CO1	Students will be able to know and apply accounting and finance theory.	K3
CO2	Students will be able to understand the mechanics of preparation of financial statements, their analysis and interpretation	K2
CO3	Students will be able to explain basic economic terms, concepts, and theories	K2
CO4	Students will be able to identify key macroeconomic indicators	K3
CO5	Applying during the project cost calculation	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	1	1	2	2	2	1	1
CO2	2	2	2	2	2	1	2	1	2	2	1	0
CO3	2	1	2	2	1	1	2	1	1	1	1	2
CO4	2	2	2	2	2	3	1	2	2	2	1	1
CO5	2	2	2	2	2	2	2	2	2	2	1	1

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	1	2	2
CO2	2	1	1	2	1

CO3	2	2	2	2	2
CO4	2	2	2	2	2
CO5	2	2	1	2	2

PCC	Course Code: DYP1111	Course Title: Pr-1: Lab-1: Analysis of Inorganic Raw Materials used in Colorant Industries	Credits = 2		
			L	T	P
	Semester: III	Total Contact Hours: 60	0	0	4

List of Prerequisite Courses

HSC (Science)

List of Courses where this course will be prerequisite

Project-II (DYP1211)

Description of relevance of this course in the B. Tech. Program

Students will understand the significance of uses of these inorganic raw materials in the chemical industry

	Course Contents (Topics and Subtopics)	Required Hours
1	Estimation by volumetric titrations of inorganic raw materials used in the dyestuff industry – sodium sulphite, sodium bisulphite, sodium metabisulphite, sodium sulphide, sodium hydrosulphite, Rongalite C, bleaching powder, sodium hypochloride, iron powder, zinc dust, hydrogen peroxide, manganese dioxide, sodium nitrite	60
	Total	**60**

List of Textbooks/Reference Books

1	Vogel's textbook of quantitative chemical analysis, G. H. JEFFERY J. BASSETT J. MENDHAM R C. DENNEY, Longman Scientific & Technical, 5th Edition

Course Outcomes (Students will be able to…..)

CO1	*Estimate* the amount of inorganic compounds present	K4+P2
CO2	*Check* the purity of compound	K3+P2
CO3	*Understand* the controlling and quantitative analysis of reducing agents	K2+P2
CO4	*Analyse* and identify the classes of metal containing reducing and oxidizing agents	K4+P2
CO5	*Identify* the reducing and oxidizing agents used for synthesis	K4+P2

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	3	2	2	3	1	2	3
CO2	2	2	2	3	3	3	2	2	3	1	2	3
CO3	2	2	2	3	3	3	2	2	3	1	2	3
CO4	3	3	3	3	3	3	2	2	2	1	2	3
CO5	3	3	3	3	3	3	2	2	3	1	2	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	2
CO2	3	2	3	3	2
CO3	3	3	2	3	2
CO4	3	3	3	2	2
CO5	3	3	3	3	2

PCC	Course Code: DYP1121	Course Title: Pr-2: Lab-2: Chromatographic Methods and Analysis	Credits = 2		
			L	T	P
	Semester: III	Total Contact Hours: 60	0	0	4

List of Prerequisite Courses

HSC (Science)

List of Courses where this course will be prerequisite

Synthesis, Analysis and Applications of Optical Brighteners (DYP1201); Project-II (DYP1211)

Description of relevance of this course in the B. Tech. Program

The students will be introduced to the several chromatographic techniques essential for the monitoring, separation and purification of organic molecules after chemical transformations.

	Course Contents (Topics and Subtopics)	Required Hours
1	TLC technique – preparation of TLC plate, finding rf value, separation of a mixture of two coloured organic compounds, detection of colourless compounds, separation of a mixture of a coloured and colourless compound and two colourless compounds	20
2	Separation and purification of organic compounds by column chromatographic techniques.	24
3	Use of flash chromatography for separation of mixture of organic molecules	16
	Total	**60**

List of Textbooks/Reference Books

1	A text book of Practical Organic Chemistry including Qualitative Organic Analysis by Arthur Israel Vogel, Ed-3, Year 1984
2	Chromatography: Basic principles, Sample preparations and Related Methods by Elsa Lundanes, Leon Reubsaet, Tyge Greibrokk

Course Outcomes (Students will be able to…..)

CO1	*Understand* the principle behind chromatographic techniques – TLC, paper and column – used for the separation of organic compounds	K2+P2
CO2	*Learn* to use the appropriate techniques for a given separation scenario	K2+P2
CO3	*Conduct* these processes in the lab independently for the separation of two or more organic compounds that may or may not be coloured	K3+P2
CO4	*Apply* these techniques whenever separation of organic compounds needs to be done	K4+P2
CO5	*Develop* methods for the separation using automated systems	K4+P2

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	1	0	0	1	1	3	1
CO2	3	2	2	2	2	2	0	0	1	1	3	1
CO3	3	3	3	3	3	2	1	1	2	2	3	2
CO4	3	3	3	3	3	2	1	1	2	2	3	3
CO5	3	3	3	3	3	2	1	2	2	2	3	3

Mapping of Course Outcomes (Cos) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	3	1
CO2	2	2	2	3	1
CO3	2	2	2	2	1
CO4	3	2	2	2	1
CO5	2	2	3	2	2

SECOND YEAR: SEMESTER – IV

PCC	Course Code: CET1105	Course Title: Transport Phenomena	Credits = 4		
			L	T	P
	Semester: IV	Total Contact Hours: 60	3	1	0

List of Prerequisite Courses
Applied Physics(PYT1205), Engineering Mathematics (MAT1301), Process Calculations (CEP1720)
List of Courses where this course will be prerequisite
This is a basic course required in special subjects that deal with flow of fluids, heat and mass transfer, etc.
Description of relevance of this course in the B. Tech. Program
This basic course introduces concepts of momentum, heat and mass transfer to students. Various other concepts such as pressure, momentum, energy are introduced as well. Laws related to conservation of momentum, energy, mass are taught. Applications of these laws to various engineering and technological situations and process equipment's are explained with the help of several problems

	Course Contents (Topics and subtopics)	Required Hours
1	Fluid Statics and applications to engineering importance.	4
2	Applications of Bernoulli's Equation, Pressure drop in pipes and Fittings,meters, and fluid moving machinery such as pumps.	10
3	Particle Dynamics, Flow through Fixed and Fluidised Beds	4
4	Equations of Continuity and Motion in laminar flows and its applicationsfor simple Couette flow and Poiseuille flow applications	6
5	Heat conduction. Convective heat transfer and concept of heat transfercoefficient.	4
6	Design and constructional aspects of exchangers: Types of flows: Concurrent, counter-current and cross flows, log mean temperature difference, double pipe and Shell and tube heat exchangers. Introduction to other heat exchangers like, PHE, finned tube heat exchangers, graphite block, etc.	10
7	Heat transfer aspects in agitated tanks, condensers, reboilers and evaporators.	6
8	Fundamentals of mass transfer: Molecular diffusion in fluids, concept ofmass transfer coefficients, and interface mass transfer.	4
9	Theories of Mass transfer, Analogies for heat and mass transfer, Empirical correlations	4
10	Mass transfer applications in simple 1-D situations.	8
	Total	**60**

List of Textbooks/ Reference Books	
1	Transport Phenomena, Bird R.B., Stewart W.E., Lightfoot E.N.
2	Fluid Mechanics, Kundu Pijush K.
3	Fluid Mechanics, F. W. White
4	Unit Operations of Chemical Engineering, McCabe, Smith

Course Outcomes (students will be able to….)		
CO1	Students should be able to calculate friction factor, pressure drop, power requirements of singe phase flow in a circular pipe	K2
CO2	Students will be able to select appropriate pump based on flow and head requirements	K3
CO3	Students should be able to calculate heat transfer coefficients and do basic sizing of double pipe and shell and tube heat exchangers	K3
CO4	Students should be able to perform preliminary sizing of phase change equipment such as reboilers and condensers	K3

CO5	Students should be able to calculate mass transfer coefficients and estimate mass transfer rates in simple situations	K3
CO6	Students should be able to understand empirical correlations and solve various equations analytically or numerically	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	1	1	1	1	1	1	3
CO2	3	3	2	3	2	1	2	1	1	1	1	3
CO3	3	3	3	3	3	1	2	2	2	1	1	3
CO4	3	3	3	3	3	1	1	1	2	1	1	3
CO5	3	3	2	3	2	1	1	1	1	1	1	3
CO6	3	3	2	3	3	1	1	1	1	1	1	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	3	1	3
CO3	2	3	3	3	3
CO4	3	3	2	3	2
CO5	3	2	1	2	1
CO6	3	3	1	2	2

PCC	Course Code **DYT1051**	**Course Title: SPL5: Technology of Naphthalene Intermediates**	Credits = **3**		
			L	T	P
	Semester - **IV**	Total Contacts hours = 45	2	1	0

List of Prerequisite Courses

HSC (Science); Technology of Benzenoid Intermediates (DYT1031); Quinonoid Intermediates - Chemistry and Technology (DYT1041)

List of Courses where this course will be prerequisite

Pr 3: Lab-3: Preparation of Intermediates (DYP1131)

Description of Relevance

To make the students understand chemistry various intermediates used for the chemical industry in general and the Dyestuff industry in particular

To make them understand the unit processes and their relevance in chemical industries.

To enable them to analyze and identify the proper synthetic and industrial methods and choose accordingly the further processes to make intermediates.

To develop in them capacity to understand proper selection of chemical processes based on economic and ecological aspects

Sr. No	**Course Contents (Topics and subtopics)**	**Reqd Hours**
1	Chemistry of Naphthalene **a.** Synthesis of naphthalene **b** Raw materials **c**. Mechanism	05
2	Introduction of Functional groups into Naphthalene and relevant technology involved. **A.** Basic Unit processes a. Sulphonation b. Nitration	10

	c. Reduction d. Halogenation **B. Sulphonation:** (i) Reaction phenomenon and conditions (ii) Sulphonating agents and solvents (iii) Work up and Material of construction (iv) Substitution in Naphthalene and substituted Naphthalene (v) Plant and process flow (vi) Safety and process control parameters **C. Nitration:** (i) Reaction phenomenon and conditions (ii) Nitrating agents and solvents (iii) Work up and Material of construction (iv) Substitution in Naphthalene and substituted Naphthalene (v) Plant and process flow (vi) Safety and process control parameters, Run away reactions **D. Reduction:** (i) Reducing agents (ii) Reduction methods (iii) Selection of best method for Naphthalene and Substituent Naphthalene (iv) Process and workup (v) Safety aspect **E. Halogenation** (i) Basic nucleophilic and Electrophilic substitution (ii) Reaction and MOC	
3	Unit Processes: a. Friedel Craft's Reaction b. Oxidation c. Ammonolysis d. Hydrolysis e. Diazotization and coupling f. Bucherer Reaction, Reverse Unit Processes: **a.** Friedel Craft's Reaction (i) Types alkylation and acylation (ii) Reagents used (iii) Products and isolation (iv) MOC **b**. Oxidation (i) Types (ii) Radical Reaction (iii) Reactor design and safety aspect **c.** Ammonolysis (i) Reaction conditions (ii) Substrate requirement and substitution pattern **d.** Hydrolysis (i) Types (ii) Reaction conditions and work up (iii) Technology **e.** Diazotization and coupling (i) Definition (ii) Types (iii) Reagents required (iv) Reaction conditions and work up (v) Process control test and MOC (vi) Reactor designing (vii) Substitution pattern and reaction conditions	10

	f. Bucherer Reaction, Reverse Specially designed for naphthalene chemistry	
4	Synthesis of naphthol, naphthylamine sulphonic acids, Bon acid and its derivatives	5
5	Case studies Commercially important bulk and specialty intermediates synthesis	5
6	Technology and safety aspects Environmental conditions and factors affecting the reaction	5
7	Separation techniques and agitation system Various agitation systems, power functions, reactor designing aspects, separation techniques: (a) Physical method (b) Chemical method	5
	Total	**45**
	List of Text Books/ Reference Books	
1	Industrial organic chemistry, Weissermal K., ArpeH.J.VCH, Weinheim, 1993	
2	Organic synthesis, Smith M B, Tata McGrow Hill, NY, 2nd Ed, 2004	
3	Chemistry of Synthetic Dyes, Lubs H. A., NY 1995	
4	Chemistry of synthetic dyes vol I, Venkatraman K., NY 1952	
5	Organic Chemistry , Clayden, Oxford Univ. Press, 2001	
	Course Outcomes (students will be able to…..)	
CO1	*Understand* the basics of Naphthalene chemistry	K2
CO2	*Conceptualize* basic unit processes for naphthalene and benzene	K2
CO3	*Analyze* the various methods for synthesis of different intermediates used in dyes	K2
CO4	*Master* the various technology and safety aspects for reactions	K2
CO5	*Know* various separation techniques used commercially and agitation systems for processes	K2
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	1	1	1	0	0	0	3	1
CO2	2	2	2	2	1	1	1	0	0	0	3	1
CO3	2	2	2	2	2	2	2	0	0	0	3	1
CO4	3	3	3	3	3	2	2	1	0	0	3	1
CO5	3	3	3	3	3	2	2	1	0	0	3	1

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	3	1
CO2	2	1	3	2	1
CO3	2	2	3	3	1
CO4	1	1	2	2	1
CO5	2	1	1	3	1

PCC	**Course Code:**	**Course Title:**	**Credits = 3**		
	DYT1061	**SPL6: Technology of Ionic Dyes - I**	**L**	**T**	**P**
	Semester: IV	**Total Contact Hours: 45**	**2**	**1**	**0**
List of Prerequisite Courses					

HSC (Science); Technology of Benzenoid Intermediates (DYT1031); Quinonoid Intermediates - Chemistry and Technology (DYT1041); Technology of Naphthalene Intermediates (DYT1051)
List of Courses where this course will be prerequisite
Technology of Ionic Dyes – II (DYT1109); **Pr 5**: Lab 5: Preparation of Ionic Dyes (DYP1151)
Description of relevance of this course in the B. Tech. Program
The subject is intended to make the students learn about various chromophores, their synthesis and properties as well as several dyes related to chromophores. The course will also focus on discussing the chemistry, properties, technology & their manufacture as well as their drawbacks

	Course Contents (Topics and Subtopics)	**Required Hours**
1	Chemistry, Technology & Manufacture of Acid Dyes	10
2	Chemistry, Technology & Manufacture of Direct Dyes	10
3	Chemistry, Technology & Manufacture of Reactive Dyes	10
4	Chemistry, Technology & Manufacture of Basic Dyes	10
5	Drawbacks of Ionic Dyes	5
	Total	**45**
	List of Textbooks/Reference Books	
1	Chemistry of Synthetic Dyes, Lubs H. A., NY 1995	
2	Chemistry of synthetic dyes vol I, Venkatraman K., NY 1952	
3	Chemistry of azo colorants Vol I and Vol II- P. Zollinger	
	Course Outcomes (students will be able to…..)	

CO1	*Explain* and define the classes of dyes, substrates	K2
CO2	*Understand* the variety and chemistry of dyes and their application	K2
CO3	*Overview* of recent trends in the field of ionic dyes	K2
CO4	*Differentiate* the Techniques of diazotization and variations available	K2
CO5	*Design* the synthesis of novel ionic based dyes	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	0	0	0	0	0	0	3	0
CO2	2	2	2	2	0	0	0	0	0	0	3	0
CO3	2	3	2	3	1	1	1	1	0	0	3	0
CO4	2	3	2	3	1	1	1	1	1	1	3	1
CO5	3	3	3	3	2	2	2	1	2	2	3	2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	1
CO2	2	2	2	2	1
CO3	2	2	2	3	1
CO4	2	2	2	3	1
CO5	2	2	2	2	1

EEM	**Course Code: CET1805**	**Course Title: Chemical Process Economics**	**Credits = 2**		
			L	**T**	**P**
	Semester: IV	**Total contact hours: 30**	**1**	**1**	**0**
List of Prerequisite Courses					
Process Calculations (CEP1720), Basics of Economics and Finance (HUT1205)					
List of Courses where this course will be prerequisite					

Project-I (DYP1191), and Project-II (DYP1211)		
Description of relevance of this course in the B. Tech. Program		
This course is required for the future professional career.		
Course Contents (Topics and subtopics)		**Required Hours**
1	Estimation of Plant and Machinery cost, Capacity Index, Cost Indices	8
2	Relationship between price of a product and project cost and cost of production, EV Analysis. Elements of cost of production, monitoring of the same in a plant, Meaning of Administrative expenses, sales expenses etc. Introduction to various components of project cost and their estimation. Project financing, debt: equity ratio, promoters, contributors, shareholders R	8
3	Project financing, debt: equity ratio, promoters, contributors, shareholders contribution, source of finance, time value of money. Concept of interest, time value of money, selection of various alternative equipment or system based on this concept. Indian norms, EMI calculations. Depreciation concept, Indian norms and their utility in estimate of working results of project. Working capital concept and its relevance to project.	8
4	Estimate of working results of proposed project. Capacity utilization, Gross profit, operating profit, profit before tax, Corporate tax, dividend, Net cash accruals. Project evaluation: Cumulative cash flow analysis Break-Even analysis, incremental analysis, various ratios analysis, Discounted cash flow analysis	6
5	Estimation of Plant and Machinery cost, Capacity Index, Cost Indices	8
	Total	**30**
List of Textbooks/ Reference Books		
1	Chemical Project Economics, MahajaniV.V.and Mokashi SM.	
2	Plant Design and Economics for Chemical Engineers, Peters M.S.,TimmerhausK.D.	
3	Process Plant and Equipment Cost Estimation, Kharbanda O.P.	
Course Outcomes (students will be able to….)		
CO1	Calculate working capital requirement for a given project	K3
CO2	Calculate cost of equipment used in a plant total project cost	K3
CO3	Calculate cash-flow from a given project	K3
CO4	Select a site for the project from given alternatives	K4
CO5	List out various milestones related to project concept to commissioning	K2
CO6	Calculate overall profitability and rate of return for a given project	K5
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	2	2	1	2	2	3	1	3	3
CO2	3	3	1	2	2	1	2	1	3	1	3	3
CO3	3	3	2	3	2	1	2	2	1	1	3	3
CO4	3	3	3	2	2	2	3	1	1	1	3	3
CO5	3	3	2	2	1	1	1	2	3	1	3	3
CO6	3	3	2	3	3	2	2	1	3	1	3	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5

CO1	2	1	2	2	3
CO2	2	1	2	1	3
CO3	2	1	2	2	1
CO4	2	2	3	1	1
CO5	1	1	1	2	3
CO6	2	1	2	2	3

VEC	**Course Code:** **HUT1206**	**Course Title:** **Environmental Science and Technology**	**Credits =2**		
			L	**T**	**P**
	Semester: IV	**Total Contact Hours: 30**	**1**	**1**	**0**

List of Prerequisite Courses

Industrial Waste Management in Colorants Industry (DYT1231)

List of Courses where this course will be prerequisite

Project-II (DYP1211)

Description of relevance of this course in the B. Tech. Program

The course is very useful for the future Chemical Engineers and Technologists for assessing and appreciating impact of chemical processes and technologies on the Environment. The students will be exposed to the nitty-gritties of the impact of design principles on the Environment. Thorough understanding of these technology aspects is going to help in innovative solutions with positive impact on the environment.

	Course Contents (Topics and subtopics)	**Required Hours**
1	Introduction to all prevailing international standards of Health, Safety, and Environment (HSE); Environmental laws and regulations; Standards (air quality, noise, water), ISO14000+	3
2	Environmental impact assessment, Life cycle assessment (LCA)	3
3	Pollution prevention in chemical manufacturing, effluent valorization	2
4	Air pollution; Air pollutants: sources (specific pollutants), effects, and dispersion modelling, air pollution, air quality, pollutants minimisation and control, fugitive emissions (source and control), Noise pollution	4
5	Wastewater treatment; Groundwater and surface water pollution, removal of specific water contaminants; Solid waste; Hazardous waste	4
6	Inherent safety; Major disasters (e.g. Flixborough, UK; Bhopal, India; Seveso, Italy; Pasadena, Texas; Texas City, Texas; Jacksonville, Florida; Port Wentworth, Georgia)	5
7	Toxicology; Industrial hygiene	2
8	Source models; Toxic release and dispersion models	5
9	Fires and explosions; Concepts to prevent fires and explosions	3
10	Chemical reactivity	2
11	Reliefs and reliefs sizing; Hazard identification; Risk assessment	4
12	Safety procedures and designs	4
13	Some case histories	4
	Total	

List of Textbooks/ Reference Books

1	Environmental Studies by R. Rajagopalan, Oxford University Press.
2	Essentials of Environmental Studies by Kurian Joseph & Nagendran, Pearson
3	Education Renewable Energy by Godfrey Boyle, Oxford Publications
4	Perspective of Environmental Studies, by Kaushik and Kaushik, New Age
5	International Environmental Studies by. Anandita Basak, Pearson Education
6	Textbook of Environmental Studies by Dave and Katewa, Cengage Learning
7	Environmental Studies by Benny Joseph, Tata McGraw Hill
8	Textbook of Environmental studies by Erach Books Bharucha, University Press.

Course Outcomes (students will be able to….)		
CO1	Calculate BOD / COD for a given composition of effluent stream, estimation of biokinetics.	K3
CO2	Calculate adiabatic lapse rate and determine conditions for suitability of atmospheric dispersion, effective stack height, chimney design.	K3
CO3	Calculate concentrative of pollutant at any point in the neighbourhood of emission given atmospheric conditions like wind, dispersion, environmental factors, etc.	K3
CO4	Calculate size/time/power required for primary clarifier, secondary treatment, tertiary treatment, sizing of different types of Biological treatments etc.	K3
CO5	Identify hazards in a given process and assess the same and provide solutions for operating safely.	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	3	3	2	3	3	3	2
CO2	3	3	2	2	0	3	3	3	3	3	3	1
CO3	3	3	0	2	2	3	1	3	3	1	3	2
CO4	3	1	2	2	2	3	3	3	3	3	0	2
CO5	3	3	2	3	2	3	3	3	3	3	3	2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	1	2
CO2	2	2	3	3	2
CO3	3	2	3	3	1
CO4	2	2	3	1	3
CO5	2	2	3	3	2

CEP/FP	Course Code: XXXXXXX	Course Title: Community Engagement Projects	Credits = 2		
			L	T	P
	Semester: IV	Total Contact Hours: 60	0	0	4
List of Prerequisite Courses					
NIL					
List of Courses where this course will be prerequisite					
NIL					
Description of relevance of this course in the B. Tech. Program					
Students will explore the various community projects as individual or group related to study of societal technological activities through various organizations.					

Course Contents (Topics and subtopics)		Required Hours
1	Chemical Technology have the main objective of making the knowledge useful for the benefit of society. In the first step, students, individually or in a group not more than 5, shall identify the problems faced by the society in their neighborhood or city, or the state. They shall collect necessary data, collate relevant information and identify a problem that can be solved using the knowledge of own field or general sciences and propose an affordable solution. The team shall then execute the project with support from Institute, Local Society groups, NGOs, Industry.	60

	OR Community service: Helping students in studies, Making colorful charts, short notes, providing coloring books and colors, Activity games, Teaching street children, Helping in school assignments, Visiting old age homes and child care Centre etc.	
	Total	**60**
List of Textbooks/ Reference Books		
1	General Books, News paper etc	
Course Outcomes (students will be able to….)		
CO1	This course will help students to contribute of social networking as a bridge between the various government schemes and the people of India. The course also outlines the benefits of community engagement through research and innovation	K2
CO2	Sensitivity towards the environment and education, safety and energy, enthusiasm towards physical, mental and spiritual health along with simple living and high thinking have been explained for better understanding of the students	K2
CO3	Students will be able to understand the various problems of any community and the possible ways to address the same	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	1	1	2	1	1	2	1	2	2
CO2	1	1	2	1	1	2	1	1	2	1	2	2
CO3	1	1	2	1	1	2	1	1	2	1	2	2

VSEC	**Course Code: DYP1131**	**Course Title: Pr-3: Lab-3: Preparation of Intermediates**	**Credits = 2**		
			L	**T**	**P**
	Semester: IV	**Total Contact Hours: 60**	**0**	**0**	**4**

List of Prerequisite Courses		
HSC (Science); Chromatographic Methods and Analysis (DYP1121)		
List of Courses where this course will be prerequisite		
All dyestuff courses		
Description of relevance of this course in the B. Tech. Program		
Students will be trained to synthesize all the kinds of intermediates required for the synthesis of dyes and pigments.		
	Course Contents (Topics and Subtopics)	**Required Hours**
1	Preparation of some fast bases and benzene intermediates	20
2	Preparation of some naphthalene intermediates	20
3	Preparation of 1-chloro-, 1,5-dinitro- and 1,4-diaminoanthraquinone	20
	Total	**60**
List of Textbooks/Reference Books		
1	Fundamental Processes Of Dye Chemistry by Hans Eduard Fierz-David And Louis Blangey	
Course Outcomes (Students will be able to…..)		
CO1	*Execute* the synthesis of different dye intermediates	K3+P2
CO2	*Purify* and isolate the intermediates	K3+P2
CO3	*Differentiate* the techniques of synthesis of different intermediate isomers	K2+P2
CO4	*Design* the synthesis, separation & isolation of dye intermediates	K4+P2
CO5	*Apply* the theoretical knowledge in the practical synthesis, separation, and isolation of the dye intermediates	K4+P2

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	2	3	2	2	0	2	0	3	3
CO2	3	3	3	2	3	3	2	0	2	0	3	3
CO3	2	3	3	2	3	3	2	0	2	0	3	3
CO4	2	3	3	2	2	3	2	1	2	2	3	3
CO5	3	3	3	3	3	3	3	2	3	2	3	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	1	2	1
CO2	2	2	1	2	1
CO3	2	1	1	1	1
CO4	1	2	1	2	1
CO5	2	2	1	2	1

THIRD YEAR: SEMESTER-V

PCC	Course Code: CET1806	Course Title: Chemical Reaction Engineering	Credits = 2		
			L	T	P
	Semester: V	Total contact hours: 30	1	1	0

List of Prerequisite Courses

Physical Chemistry (CHT1405), Process Calculations (CEP1720), Transport Phenomena (CET1105)

List of Courses where this course will be prerequisite

Chemical engineering laboratory (CEP1714), Project-I (DYP1191), and Project-II (DYP1211)

Description of relevance of this course in the B. Tech. Program

Chemical Reaction Engineering is concerned with the utilization of chemical reactions on a commercial scale. This course is very relevant but not limited to the following industries: Inorganic chemicals, organic chemicals, petroleum & petrochemicals, Pulp & paper, Pigments & paints, rubber, plastics, synthetic fibers, Foods, Dyes and intermediates, Oils, oleochemicals, and surfactants, Minerals, clean sing agents, Polymers and textiles, Biochemical and biotechnology, pharmaceuticals and drugs, Microelectronics, energy from conventional and non-conventional resources, Metals.

	Course Contents (Topics and subtopics)	Required Hours
1	Kinetics of homogeneous reactions, Interpretation of batch reactor data, Single ideal reactors including design aspects	8
2	Multiple reactions, Temperature, and pressure effects	3
3	Introduction to Non ideal flow, RTD measurements, Models to predict conversions	2
4	Homogeneous and Heterogeneous Catalysis, Kinetics of Solid Catalyzed Reactions. Design of gas – solid catalytic reactors	8
5	Introduction to Multiphase reactors	4
6	Mass transfer with chemical Reactions: Regimes of operation and Model contactors	5
	Total	**30**

List of Textbooks/ Reference Books

1	Elements of Chemical Reaction Engineering – H.Scott Fogler
2	Heterogeneous Reactions, Vol.I and II –L.K. Doraiswamy, M.M.Sharma

Course Outcomes (students will be able to….)

CO1	Estimate kinetics of chemical reaction based on laboratory data	K3
CO2	Derive design expressions for ideal reactor systems such as batch, plug flow and continuous stirred tank reactor	K3
CO3	Estimate conversion, yield and selectivity for different chemical reactions	K3
CO4	Compare various reactors and select an appropriate reactor for a given situation	K4
CO5	Select appropriate multiphase reactor based on reaction chemistry, heat and mass transfer aspects	K4
CO6	Identify rate controlling mechanism of a given reaction system involving mass transfer	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	2	1	1	3
CO2	3	3	3	3	3	1	1	1	2	1	1	3
CO3	3	3	3	2	2	1	1	1	1	1	1	3
CO4	3	3	3	3	2	1	3	1	1	1	1	3
CO5	3	3	3	3	1	2	1	1	2	1	1	3
CO6	3	3	3	3	2	1	1	1	2	1	1	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	1	1	3
CO2	3	3	2	2	3
CO3	2	2	1	1	2
CO4	3	2	1	3	3
CO5	3	1	2	1	3
CO6	3	2	1	1	3

PCC	**Course Code: CET1807**	**Course Title: Chemical Engineering Operations**	**Credits =2**		
			L	**T**	**P**
	Semester: V	**Total contact hours: 30**	**1**	**1**	**0**

List of Prerequisite Courses

Process Calculations (CEP1720), Transport Phenomena (CET1105)

List of Courses where this course will be prerequisite

Project-I (DYP1191), and Project-II (DYP1211)

Description of relevance of this course in the B. Tech. Program

This is an applied Chem Engg. subject. The principles learnt in this course are required in the dyestuff technology courses and throughout the professional career of student

Course Contents (Topics and subtopics)		**Required Hours**
1	**Distillation**: Fundamentals of flash, batch and continuous distillation, distillation columns internals, steam and azeotropic distillation	10
2	**Liquid-Liquid Extraction**: Solvent selection, construction of ternary diagrams, staged calculations, types of extraction equipment.	5
3	**Crystallization**: Phase diagram (temp/solubility relationship), evaporative and cooling crystallization, introduction to different types of crystallizers	5

4	**Filtration**: Mechanism of filtration, basic equation, constant volume, constant pressure filtration, rate expressions with cake and filter cloth resistances, compressible and incompressible cakes, introduction to various types of filters	5
5	**Drying**: Drying mechanism, drying rate curves, estimation of drying time and types of dryers	5
	Total	**30**

List of Textbooks/ Reference Books	
1	Richardson, J.F., Coulson, J.M., Harker, J.H., Backhurst, J.R., 2002. Chemical engineering: Particle technology and separation processes. Butterworth-Heinemann, Woburn, MA.
2	Seader, J.D., Henley, E.J., 2005. Separation Process Principles, 2 ed. Wiley, Hoboken, N.J.
3	Svarovsky, L., 2000. Solid-Liquid Separation. Butterworth-Heinemann, Woburn, MA.
4	McCabe, W., Smith, J., Harriott, P., 2004. Unit Operations of Chemical Engineering, 7 ed. McGraw-Hill Science/Engineering/Math, Boston.
5	Green, D., Perry, R., 2007. Perry's Chemical Engineers' Handbook, Eighth Edition, 8 ed. McGraw-Hill Professional, Edinburgh.
6	Dutta, B.K., 2007. Principles of Mass Transfer and Separation Process. Prentice-Hall of India Pvt. Ltd, New Delhi.

Course Outcomes (students will be able to….)		
CO1	Understand and compare various unit operations used in the chemical and allied industries	K3
CO2	Perform preliminary sizing of continuous and batch distillation columns	K3
CO3	Analyze filtration data and select systems based on requirements, estimate filtration area for given requirements, understand filter aids and their usage	K4
CO4	Construct ternary equilibrium diagram based on laboratory scale experimental data	K3
CO5	Understand the working principle of various industrial extraction, crystallization, filtration and drying equipment	K2
CO6	Select and carry out preliminary sizing of various industrial extraction, crystallization, filtration and drying equipment	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	1	1	1	1	2	1	1	3
CO2	3	2	3	3	2	2	1	2	2	1	1	3
CO3	3	3	3	2	2	1	1	2	2	1	1	3
CO4	3	3	2	2	3	1	1	2	2	1	1	3
CO5	3	2	2	2	1	1	1	1	2	1	1	3
CO6	3	3	2	2	3	2	2	2	2	1	1	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	2	2	1	3
CO3	2	2	3	2	2
CO4	2	2	1	1	2
CO5	2	2	3	2	2
CO6	3	3	2	2	3

PCC	**Course Code:**	**Course Title:**	**Credits = 4**

	DYT-1071	SPL7: Technology of Non-ionic Dyes - I	L	T	P
	Semester: V	Total Contact Hours: 60	3	1	0

List of Prerequisite Courses

HSC (Science); A Primer on Technology of Intermediates and Dyestuffs (DYT1011); Technology of Benzenoid Intermediates (DYT1031); Quinonoid Intermediates - Chemistry and Technology (DYT1041); Technology of Naphthalene Intermediates (DYT1051); Technology of Ionic Dyes-I (DYT1061)

Description of relevance of this course in the B. Tech. Program

Technology of Non-ionic Dyes – II (DYT1131); **Pr 6**: Lab-6: Preparation of Non-ionic Dyes (DYP1161)

The subject is intended to make the students learn about various chromophores, their synthesis and properties as well as several dyes related to chromophores. The course will also focus on discussing the chemistry, properties, technology & their manufacture as well as their drawbacks

	Course Contents (Topics and Subtopics)	Required Hours
1	Chemistry, Technology & Manufacture of Disperse Dyes	15
2	Chemistry, Technology & Manufacture of Oxidation colorants	15
3	Chemistry, Technology & Manufacture of Vat Dyes	15
4	Chemistry, Technology & Manufacture of Sulfur Dyes	15
5	Drawbacks of Non-ionic Dyes	15
	Total	**60**

List of Textbooks/Reference Books

1	Chemistry of Synthetic Dyes, Lubs H. A., NY 1995
2	Chemistry of synthetic dyes vol I, Venkatraman K., NY 1952
3	Chemistry of azo colorants Vol I and Vol II- P. Zollinger

Course Outcomes (Students will be able to…..)

CO1	Explain and define the classes of dyes, substrates	K2
CO2	Understand the variety and chemistry of dyes and their application	K2
CO3	Overview of recent trends in this field of dyes	K2
CO4	Differentiate the techniques of for synthesis different non-ionic dyes	K2
CO5	Design the synthesis of novel non-ionic based dyes	K3

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO12
CO1	2	2	2	2	0	0	0	0	0	0	3	0
CO2	2	2	2	2	0	0	0	0	0	0	3	0
CO3	2	3	2	3	1	1	1	1	0	0	3	0
CO4	2	3	2	3	1	1	1	1	1	1	3	1
CO5	3	3	3	3	2	2	2	1	2	2	3	2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	2	1
CO2	3	1	2	1	1
CO3	2	1	3	2	1
CO4	1	1	1	1	1
CO5	1	1	3	2	1

PCC	Course Code:	Course Title:	Credits = 2

	DYP1141	Pr-4: Lab-4: Analysis of Colorants and Fibers	L	T	P
	Semester: V	**Total Contact Hours: 60**	**0**	**0**	**4**

List of Prerequisite Courses

HSC (Science); Physical and Chemical Constitution of Colorants (DYT1021); Chromatographic Methods and Analysis (DYP1121)

List of Courses where this course will be prerequisite

Pr 8: Lab-8: Synthesis, Analysis and Applications of Optical Brighteners (DYP1201); Project-II (DYP1211)

Description of relevance of this course in the B. Tech. Program

The students will be trained to analyse several intermediates of dyes, dyes and fibres by chemical tests.

	Course Contents (Topics and Subtopics)	Required Hours
1	To analyze the purity of amine by the method of Diazotization– aniline, sulphanilic acid, chloroanilines, toluidines, anisidines, etc	20
2	Coupling experiments- Estimation of phenols and naphthols by bromination – phenol, 2-naphthol, R-acid, etc	20
3	Estimation of naphtholsulphonic acids and aminonaphtholsulphonic acids by diazo-coupling – Schaffer acid, R salt, gamma acid, J acid, etc	20
4	Estimation of dyes by reduction – Sunset Yellow, Ponceau 4R, Orange II, Tartrazine, etc	20
5	Identification of dyes – acid, basic, direct, acid mordant, vat, sulphur	20
6	Identification of fibres – cotton, wool, silk, nylon, polyester	20
	Total	**120**

List of Textbooks/Reference Books

1	Chemistry of Synthetic Dyes – Vol I, Venkataraman, K., Academic Press, 1952
2	Synthesis and Application of Dyes, Rys and Zollinger
3	The Chemistry of Synthetic Dyes – Vol II, Venkataraman K., Academic Press
4	The Chemistry of Synthetic Dyes – Vol IV, Venkataraman K., Academic Press
5	The Chemistry of Synthetic Dyes – Vol VI, Venkataraman K., Academic Press
6	The Chemistry of Synthetic Dyes and Pigments, Lubs H. A., Robert E. Krieger Publishing Co

Course Outcomes (Students will be able to…..)

CO1	Analyse the purity of the amines used for dye synthesis	K3+P3
CO2	Check the presence of coupling components purity required for final dye synthesis	K2+P2
CO3	Understand & analyse the presence of diazo groups and reducible groups in the given dye structure	K4+P3
CO4	Learn to estimate the various dyes	K4+P2
CO5	Identify the classes of dyes from the application-oriented perspective	K5+P2

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	3	2	2	2	0	2	1	3	3
CO2	3	3	3	3	3	2	2	0	2	1	3	3
CO3	3	3	3	3	3	2	1	0	2	1	3	3
CO4	3	3	3	3	3	2	1	0	2	1	3	3
CO5	3	3	3	3	3	2	1	0	2	1	3	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	1	2	2
CO2	1	2	1	3	2

CO3	1	2	1	3	2
CO4	2	3	2	2	2
CO5	2	2	2	3	2

PCC	**Course Code:** DYP1151	**Course Title:** Pr-5: Lab-5: Preparation of Ionic Dyes	**Credits = 2**		
			L	**T**	**P**
	Semester: V	**Total contact hours:** 60	0	0	4

List of Prerequisite Courses

HSC (Science); Technology of Ionic Dyes-I (DYT1061)

List of Courses where this course will be prerequisite

Technology of Ionic Dyes – II (DYT1109)

Description of relevance of this course in the B. Tech. Program

Students will be trained to synthesize various kinds of ionic dyes

	Course Contents (Topics and subtopics)	**Reqd. hours**
1	Preparation of several ionic dyes by various techniques	20
2	Preparation of several ionic dyes with different components – acidic and alkaline coupling	20
3	Preparation of some Acid, Direct, Reactive, & Basic Dyes	20
	Total	**60**
	List of Text Books	
1	Fundamental Processes Of Dye Chemistry by Hans Eduard Fierz-David And Louis Blangey	
2	Chemistry and applications of dyes by Warring and Hallas	
	List of Additional Reading Material / Reference Books	
1	Chemistry of Synthetic Dyes – Vol II, Venkataraman, K., Academic Press, 1952	
2	Chemistry of Synthetic Dyes – Vol IV, Venkataraman, K., Academic Press, 1972	
	Color Chemistry –Synthesis, Properties and Applications of Dyes and Pigments, Zollinger H., 2nd ed., Weinheim – VCH, 1991	
	Course Outcomes (students will be able to…..)	
CO1	Execute the synthesis of different classes of ionic dyes	K3+P3
CO2	Able to purify and isolate the ionic dyes	K3+P2
CO3	Differentiate the methods of synthesis of different classes of ionic dyes	K3+P2
CO4	Design & develop practical skills in the synthesis, separation and isolation of the ionic dyes	K4+P3

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	2	3	2	2	0	2	0	3	3
CO2	3	3	3	2	3	3	2	0	2	0	3	3
CO3	2	3	3	2	3	3	2	0	2	0	3	3
CO4	2	3	3	2	2	3	2	1	2	2	3	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	1	2	2
CO2	2	1	2	2	2
CO3	2	1	2	2	2
CO4	2	1	2	2	2

THIRD YEAR: SEMISTER-VI

PCC	Course Code: DYT1109	Course Title: SPL9: Technology of Ionic Dyes - II	Credits = 3		
			L	T	P
	Semester: VI	Total Contact Hours: 45	2	1	0

List of Prerequisite Courses

HSC (Science); Technology of Ionic Dyes-I (DYT1061)

List of Courses where this course will be prerequisite

Pr 8: Lab-8: Synthesis, Analysis and Applications of Optical Brighteners (DYP1201)

Description of relevance of this course in the B. Tech. Program

The subject is intended to make the students learn about various chromophores, their synthesis and properties as well as several dyes related to chromophores. The course will also focus on discussing the chemistry, properties, technology & their manufacture as well as their drawbacks

	Course Contents (Topics and Subtopics)	Required Hours
1	Chemistry & Technology of Reactive Dyes	10
2	Manufacture of Reactive Dyes	10
3	Chemistry & Technology of Basic Dyes	10
4	Manufacture of Basic Dyes	10
5	Drawbacks of Ionic dyes	5
	Total	**45**

List of Textbooks/Reference Books

1	Chemistry of Synthetic Dyes, Lubs H. A., NY 1995
2	Chemistry of synthetic dyes vol I, Venkatraman K., NY 1952
3	Chemistry of azo colorants Vol I and Vol II- P. Zollinger

Course Outcomes (students will be able to…..)

CO1	*Explain* and define the classes of dyes, substrates	K2
CO2	*Understand* the variety and chemistry of dyes and their application	K2
CO3	*Overview* of recent trends in the field of ionic dyes	K2
CO4	*Differentiate* the Techniques of diazotization and variations available	K2
CO5	*Design* the synthesis of novel ionic based dyes	K3

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	2	2	2	2	0	0	0	0	0	0	3	0
CO2	2	2	2	2	0	0	0	0	0	0	3	0
CO3	2	3	2	3	1	1	1	1	0	0	3	0
CO4	2	3	2	3	1	1	1	1	1	1	3	1
CO5	3	3	3	3	2	2	2	1	2	2	3	2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	1
CO2	2	1	2	2	2
CO3	2	2	2	1	2
CO4	2	2	2	1	2
CO5	2	2	2	2	2

PCC	**Course Code:** DYT1111	**Course Title:** SPL10: Structural Elucidation of Dyes	**Credits = 3**		
			L	**T**	**P**
	Semester: VI	**Total contact hours: 45**	**2**	**1**	**0**

List of Prerequisite Courses		
HSC (Science); Analytical Chemistry (CHT1406)		
List of Courses where this course will be prerequisite		
Project-II (DYP1211)		
Description of relevance of this course in the B. Tech. Program		
The students will learn the basics of spectroscopy and will be able to elucidate the molecular structure of unknown molecules by analyzing the several spectroscopic data		
	Course Contents (Topics and subtopics)	**Reqd. hours**
1	Introduction to spectral methods of analysis. UV-Visible spectroscopy.	05
2	NMR spectroscopy of synthetic dyes: Principles, some basic terms. Shielding and de-shielding, chemical shift in 1H-NMR spectroscopy, Magnetic Anisotropy, Spin-Spin coupling and splitting in 1NMR spectroscopy, Coupling constant, analysis of 1H-NMR spectrum. Details of water-insoluble azo, disperse anthraquinone, cationic and acid dyes.	10
3	IR-Spectroscopy of synthetic dyes: Basic theory, fingerprint region, treatment to identify functional groups, structure elucidation.	10
4	Mass spectroscopy of synthetic dyes: Basic terms and nitrogen rule. Mass Spectral Data, Representation of fragmentation process, factors governing fragmentation process, examples of common types of fragmentation. Details of anthraquinone, azo, cationic, acid and methine dyes.	05
5	Combined use of IR, NMR and Mass spectroscopy for dyes structures elucidation.	15
List of Text Books		
1	The Analytical Chemistry of Synthetic Dyes by K. Venkatraman	
2	Introduction to Spectroscopy by Donald L.Pavia, Gary M. Lampman, George S.Kriz, James R.Vyvyan	
List of Additional Reading Material / Reference Books		
1	Spectroscopic identification of Organic Compounds by Robert M.Silverstein, Francis X.Webster, David Kiemle	
	Course Outcomes (students will be able to…..)	
CO1	Understand the basic concepts of spectroscopy	K2
CO2	Demonstrate knowledge in analyzing the UV and IR spectra	K2
CO3	Analyze the NMR spectra	K3
CO4	Solve complicated spectral problems	K4
CO5	Assess the mass spectroscopic spectra	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	1	0	1	1	0	3	0
CO2	3	3	3	3	2	1	0	1	1	0	3	0
CO3	3	3	3	3	2	1	0	1	1	0	3	0
CO4	3	3	3	3	2	1	0	1	2	2	3	2
CO5	3	3	3	3	2	2	0	1	2	2	3	2

Mapping of Course Outcomes (Cos) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	1
CO2	2	2	2	2	1
CO3	2	2	2	2	1
CO4	2	2	2	2	1
CO5	2	2	1	2	1

PCC	**Course Code:** **DYT1131**	**Course Title:** **SPL12: Technology of Non-ionic Dyes - II**	**Credits = 4**		
			L	**T**	**P**
	Semester: VI	**Total Contact Hours: 60**	**3**	**1**	**0**

List of Prerequisite Courses

HSC (Science); Technology of Non-ionic Dyes – I (DYT1071)

List of Courses where this course will be prerequisite

Pr 6: Lab-6: Preparation of Non-ionic Dyes (DYP1161);

Description of relevance of this course in the B. Tech. Program

The subject is intended to make the students learn about various chromophores, their synthesis and properties as well as several dyes. The course will also focus on discussing the chemistry, properties, technology & their manufacture as well as their drawbacks

	Course Contents (Topics and Subtopics)	**Required Hours**
1	Chemistry & Technology of Vat Dyes	15
2	Chemistry & Technology of Sulfur Dyes	15
3	Manufacture of Vat & Sulfur Dyes	25
4	Drawbacks of non-ionic dyes	5
	Total	**60**

List of Textbooks/Reference Books

1	Chemistry of Synthetic Dyes, Lubs H. A., NY 1995
2	Chemistry of synthetic dyes vol I, Venkatraman K., NY 1952
3	Chemistry of azo colorants Vol I and Vol II- P. Zollinger

Course Outcomes (Students will be able to…..)

CO1	Explain and define the classes of dyes, substrates	K2
CO2	Understand the variety and chemistry of dyes and their application	K2
CO3	Overview of recent trends in this field of dyes (K2)	K2
CO4	Differentiate the techniques of for synthesis different non-ionic dyes	K2
CO5	Design the synthesis of novel non-ionic based dyes	K2

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO12
CO1	2	2	2	2	0	0	0	0	0	0	3	0

CO2	2	2	2	2	0	0	0	0	0	0	3	0
CO3	2	3	2	3	1	1	1	1	0	0	3	0
CO4	2	3	2	3	1	1	1	1	1	1	3	1
CO5	3	3	3	3	2	2	2	1	2	2	3	2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	2	2	1	3
CO3	2	2	3	2	2
CO4	2	2	1	1	2
CO5	2	2	3	2	2

VESC	**Course Code:** **CEP1714**	**Course Title: Chemical Engineering Laboratory**	**Credits = 2**		
			L	**T**	**P**
	Semester: VI	**Total contact hours: 60**	**0**	**0**	**4**

List of Prerequisite Courses

Process Calculations (CEP1720), Transport Phenomena (CET1105), Chemical Reaction Engineering (CET1806) Chemical Engineering Operations (CET1807)

List of Courses where this course will be prerequisite

Project-I (DYP1191), and Project-II (DYP1211)

Description of relevance of this course in the B. Tech. Program

Chemical Engineering lab provides technology students the firsthand experience of verifying various theoretical concepts learnt in theory courses. It also exposes them to practical versions of typical chemical engineering equipment's and servers as a bridge between theory and practice. This particular lab focuses on fluid dynamics, distillation, filtration, drying and sedimentation.

Course Contents (Topics and subtopics)		**Required Hours**
1	4 - 6 Experiments on fluid dynamics and heat transfer	24
2	3 - 5 Experiments on Chemical Engineering Operations	16
3	2 – 4 Experiments on Reaction Engineering	12
4	1 – 3 Experiments on process dynamics and control	8
	Total	**60**

List of Textbooks/ Reference Books

1	McCabe W.L., Smith J.C., and Harriott P. Unit Operations in Chemical Engineering, 2014
2	Bird R.B., Stewart W.E., and Lightfoot, E.N. Transport Phenomena, 2007
3	Coulson J.M., Richardson J.F., and Sinnott, R.K. Coulson & Richardson's Chemical Engineering: Chemical engineering design, 1996.
4	Green D. and Perry R. Perry's Chemical Engineers' Handbook, Eighth Edition, 2007.

Course Outcomes (students will be able to….)

CO1	Learn how to experimentally verify various theoretical principles	K3+P2
CO2	Visualize practical implementation of chemical engineering equipment	K4+P2
CO3	Perform statistical analysis of experimental data	K4+P2
CO4	Get hands on experience with various measurement devices	K2+P2
CO5	Develop empirical correlations based on the experimental data generated	K5+P2
CO6	Generate meaningful tables and graphs	K3+P2

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	2	1	3	3	2	1	3
CO2	3	3	3	2	1	1	1	2	3	1	1	3
CO3	3	3	2	3	3	1	1	3	3	1	1	3
CO4	3	3	2	2	3	1	1	2	3	1	1	3
CO5	3	3	3	3	3	1	1	1	3	1	1	3
CO6	3	3	3	2	3	1	1	2	3	1	1	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	3	2
CO2	2	1	1	2	3
CO3	3	3	1	3	3
CO4	2	2	2	3	2
CO5	2	1	1	2	1
CO6	3	3	3	3	3

PCC	**Course Code:** DYP1161	**Course Title:** Pr-6: Lab-6: Preparation of Non-ionic Dyes	**Credits =** 2		
			L	**T**	**P**
	Semester: VI	**Total contact hours:** 60	0	0	4

List of Prerequisite Courses		
HSC (Science); Technology of Non-ionic Dyes – I (DYT1071); Technology of Non-ionic Dyes-II (DYT1131)		
List of Courses where this course will be prerequisite		
Pr 8: Lab-8: Synthesis, Analysis and Applications of Optical Brighteners (DYP1201)		
Description of relevance of this course in the B. Tech. Program		
Students will be trained to synthesize various kinds of non-ionic dyes		
Students will learn about several Non-ionic dyes		
	Course Contents (Topics and subtopics)	**Reqd. hours**
1	Preparation of several non-ionic azo dyes by various methods of diazotization techniques	20
2	Preparation of several non-ionic azo dyes with different coupling components – acidic and alkaline coupling	20
3	Preparation of some disperse dyes	20
	Total	**60**
List of Text Books		
1	Fundamental Processes Of Dye Chemistry by Hans Eduard Fierz-David And Louis Blangey	
2	Chemistry and applications of dyes by Warring and Hallas	
List of Additional Reading Material / Reference Books		
1	Chemistry of Synthetic Dyes – Vol II, Venkataraman, K., Academic Press, 1952	
2	Chemistry of Synthetic Dyes – Vol IV, Venkataraman, K., Academic Press, 1972	
	Color Chemistry –Synthesis, Properties and Applications of Dyes and Pigments, Zollinger H., 2nd ed., Weinheim – VCH, 1991	
Course Outcomes (students will be able to…..)		
CO1	Execute the synthesis of different class of non-ionic dyes	K3+P3

CO2	Able to purify and isolate the non-ionic dyes	K3+P3
CO3	Differentiate the methods of synthesis of different classes of non-ionic dyes	K3+P3
CO4	Design & develop the synthesis, separation & isolation of non-ionic dye	K4+P3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	2	3	2	2	0	2	0	3	3
CO2	3	3	3	2	3	3	2	0	2	0	3	3
CO3	2	3	3	2	3	3	2	0	2	0	3	3
CO4	2	3	3	2	2	3	2	1	2	2	3	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	1	2	1
CO2	2	2	2	2	1
CO3	2	3	2	2	1
CO4	3	2	2	2	1

PCC	**Course Code:** **DYP1171**	**Course Title:** **Pr-7: Lab-7: Application of Colorants**	**Credits = 2**		
			L	**T**	**P**
	Semester: VI	**Total Contact Hours: 60**	**0**	**0**	**4**

List of Prerequisite Courses

HSC (Science); Analysis of Colorants & Fibers (DYP1141)

List of Courses where this course will be prerequisite

Applications of Organic Colorants (DYT1211); Project-II (DYP1211)

Description of relevance of this course in the B. Tech. Program

To make the students understand chemistry various substrates and their coloration processes.

To make them understand the dyeing processes and the machineries involved

To enable them to understand the properties of substrates in relation to the properties of dyes used for their coloration.

To develop in them capacity understand proper selection of the colorants based on their structural diversities.

	Course Contents (Topics and Subtopics)	**Required Hours**
1	General considerations of the application of different classes of synthetic dyes to important textile fibres	08
2	Introduction to physicochemical principles involved in dyeing	02
3	Dye Class specific dyeing methods and dyeing machinery	15
4	Preparation of fabrics for Dyeing and printing, Ingredients of Print Paste, Selection of Ingredients of Print paste	10
5	Basic Styles of Printing	10
6	Methods of Printing	10
7	Fastness requirements of coloured fabrics	5
	Total	**60**

List of Textbooks/Reference Books

1	Experimental Dyeing by Giles, SDC
2	Textile Dyeing, V A Shenai
3	Textile Printing, V A Shenoi

4	Textile Fibres V A Shenoi

Course Outcomes (Students will be able to…..)		
CO1	Identify and define the applications of different classes of synthetic dyes with the physio-chemical principles involved in dyeing, preparation of fabric for dyeing and printing	K3+P2
CO2	Understand dyeing machinery	K3+P3
CO3	List and understand the function of the ingredients used in printing paste	K3+P2
CO4	Understand and explain basic styles of printing	K4+P3
CO5	Understand and describe methods of printing	K2+P3

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	2	2	2	2	2	2
CO2	3	3	3	3	3	3	2	2	2	2	2	2
CO3	3	3	3	3	3	3	2	2	2	2	2	2
CO4	3	3	3	3	3	3	2	2	2	2	2	2
CO5	3	3	3	3	3	3	2	2	2	2	2	2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	1	1	1
CO2	2	1	2	2	1
CO3	1	1	2	2	1
CO4	2	2	1	2	1
CO5	1	2	2	2	1

FINAL YEAR: SEMESTER-VII

PCC	**Course Code:** DYT 1151	**Course Title:** SPL13: High Performance Pigments	**Credits = 3**		
			L	**T**	**P**
	Semester: VII	**Total contact hours: 45**	2	1	0

List of Prerequisite Courses

HSC (Science); A Primer on Technology of Intermediates and Dyestuffs (DYT1011)

List of Courses where this course will be prerequisite

Honors-III **(**Case Studies in Colorants Industry**) (**DYT1191)

Description of relevance of this course in the B. Tech. Program

This course will introduce the students about various inorganic and organic high performance pigments and their synthesis and applications

	Course Contents (Topics and subtopics)	**Reqd. hours**
1	Introduction to Organic and inorganic high-performance pigments	2
2	Global Market of High-Performance pigments, Chemical and physical characterization of high performance organic pigments, Regulatory aspects of high performance pigments	3
3	Inorganic High-performance pigments: Bismuth vanadates, Cadmium pigments, Cerium pigments, Complex inorganic pigments, Titanate pigments, Special Effect pigments, IR reflecting complex-colored inorganic pigments and their manufacture, applications and properties, chemical and physical properties, dispersibility, fastness properties, and applications	10

4	Azo-High Performance Pigments: Benzimidazolone, Disazo-condensation pigments, their synthesis, manufacturing technology, physical and chemical properties, applications	3
5	Diketopyrrolopyrrole (DPP) pigments, their synthesis, manufacturing technology, physical and chemical properties, applications	3
6	Dioxazine pigments, their synthesis, manufacturing technology, physical and chemical properties, solid state properties, applications	3
7	Isoindoline pigments, their synthesis, manufacturing technology, physical and chemical properties, applications	3
8	Perylene pigments, their synthesis, manufacturing technology, physical and chemical properties, applications	3
9	Phthalocyanine pigments, their synthesis, manufacturing technology, physical and chemical properties, applications	3
10	Quinacridone pigments, their synthesis, manufacturing technology, physical and chemical properties, applications	3
11	Quinophthalone pigments, their synthesis, manufacturing technology, physical and chemical properties, applications	3
12	Imidazolone-annellated triphenedioxazine pigments, their synthesis, manufacturing technology, physical and chemical properties, applications	3
13	Vat pigments and anthraquinone pigments, their synthesis, manufacturing technology, physical and chemical properties, applications	3
	Total	**45**
List of Text Books		
1	Chemistry of Synthetic Dyes and Pigments, Lubs H. A., Robert E Krieger Publishing	
2	Industrial Inorganic Pigments Edited by G. Buxbaum and G. Pfaff, Wiley VCH	
3	Chemistry of Synthetic Dyes – Vol II, Venkataraman K., Academic Press, New York, 1952	
4	Industrial Organic Pigments – Production, Properties, Applications, Herbst W. and Hunger K., VCH Verlag, Weinheim, 1997.	
5	High Performance Pigments, Smith H. M.	
List of Additional Reading Material / Reference Books		
1	The Colour Science of Dyes and Pigments, R. McLaren Bristol, Adam Hilger Ltd., 1983	
2	Color Chemistry –Synthesis, Properties and Applications of Dyes and Pigments, Zollinger H., 2nd ed., Weinheim – VCH, 1991	
	Course Outcomes (students will be able to…..)	
CO1	*Differentiate* between pigments and high-performance pigments	K2
CO2	*Conceptualize* the basic pigmentary features which classify them HPP, etc	K2
CO3	*Classify* the pigments based on chemical constitution and color	K3
CO4	*Correlate* and predict various application properties of the HPP	K3
CO5	*Design* the synthesis and manufacturing technology of HPP	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	2	1	1	2	3	3	3	3	1
CO2	2	2	2	2	2	2	2	1	3	3	1	2
CO3	2	2	0	3	2	2	2	2	3	3	2	3
CO4	3	2	3	1	3	2	2	3	3	0	3	3
CO5	3	3	3	3	3	2	2	3	3	3	3	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	1

CO2	3	1	2	1	1
CO3	2	2	2	3	1
CO4	2	3	2	2	1
CO5	3	2	3	2	3

PCC	**Course Code:** **DYT1161**	**Course Title** **Chemistry and Technology of Fluorescent Colorants**	**Credits = 2**		
			L	**T**	**P**
	Semester: VII	**Total Contact Hours: 30**	**1**	**1**	**0**

List of Prerequisite Courses

HSC (Science); A Primer on Technology of Intermediates and Dyestuffs (DYT1011)

List of Courses where this course will be prerequisite

Honors-III **(**Case Studies in Colorants Industry**) (**DYT1191)

Description of relevance of this course in the B. Tech. Program

To make the students understand physics and chemistry of fluorescent colorants used in colorants industry. To make them understand the structure and synthesis of fluorescent colorants. To enable them to analyse and identify the proper synthetic and industrial method and choose accordingly the further processes to make fluorescent dyes.

	Course Contents (Topics and Subtopics)	**Required Hours**
1	Introduction to luminescence phenomena. Various terms like intersystem crossing, internal conversion, Stokes shift, and fluorescence quantum yield. Energy Level diagrams. Singlet and triplet states.Franck-Condon principle, Kasha's rule. Quantum mechanically allowed transitions, Charge transfer mediated effects	06
2	Stilbene based optical whiteners and fluorescent dyes	06
3	Coumarin and carbostyryl based optical whiteners and fluorescent dyes	06
4	Pyrazoline, naphthaliminde, benzanthrone, and azabenzanthrone based fluorophores	06
5	Water soluble fluorescent dyes, Cyanine dyes, xanthenes, oxazines, and similar dyes. BODIPY and their Aza analogues	06
	Total	**30**

List of Textbooks/Reference Books

1	Molecular Fluorescence: Principles and Applications by B Valeur, Wiley VCH
2	Principles of Fluorescence Spectroscopy J R Lackowiz, Springer

Course Outcomes (Students will be able to…..)

CO1	*Understand* the basics of fluorescence	K2
CO2	*Conceptualized* the basic fluorophores	K2
CO3	*Analyze* the various fluorophores for optical whitening, and functional applications	K3
CO4	*Know* the various aspects of water-soluble fluorescent dyes in biology.	K2
CO5	*Identify* the synthetic route for a desired fluorescent dye	K2

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	1	1	0	0	0	0	2	0
CO2	2	2	2	2	2	1	0	0	0	0	2	0
CO3	2	3	3	2	2	1	2	0	2	2	2	2
CO4	2	2	2	3	2	1	2	0	1	1	2	1
CO5	2	3	3	3	2	2	2	1	2	2	3	2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5

CO1	2	2	3	2	1
CO2	2	2	2	2	1
CO3	2	2	1	2	1
CO4	2	1	2	2	1
CO5	2	2	2	2	2

RM_1	Course Code: DYP1181	Course Title: Literature Review (Research Methodology-I)	Credits = 2		
			L	T	P
	Semester: VII	Total contact hours: 30	1	0	2

List of Prerequisite Courses

Communication Skills (HUP1110B)

List of Courses where this course will be prerequisite

Project-I (DYP1191) and Project-II(DYP1211)

Description of relevance of this course in the B. Tech. Program

The formal exposure to various elements of research methods such as problem formulation, literature search, planning of various activities, documentation, budgeting, purchase, report/thesis compilation, manuscript writing, patent drafting, is critical for polishing the naïve research attitude and aptitude in the PG students of the programme. The course is designed to formally introduce various concepts of research methodology in stepwise manner to the students

	Course Contents (Topics and subtopics)	Required Hours
1	Introduction of Course Academic Honesty Practices General philosophy of science & Arguing About Knowledge Case studies in science history	2
2	Motivation and Background Motivation/Demotivation for Research, Building Background for Research and How to read research papers	2
3	Time Management (Academic and Non-academic time), Effort Management, Plan execution, Energy Management Issue, Role and expectation of research supervisor and student	3
4	Finding and Solving Research Problems What is Research, How to start?, Approaches to find research problems and psychological experiments Literature survey, Textbooks, Review and research papers How to ask Questions What is worthwhile research problem, Analytical and synthetic research approach	3
5	Finding and Solving Research Problems What is Research, How to start?, Approaches to find research problems and psychological experiments Literature survey, Textbooks, Review and research papers, critical review of research papers, how to write literature survey report, How to ask Questions, formulating research questions,	4
6	What is worthwhile research problem, Analytical and synthetic research approaches How to solve research problems, designing work plan, importance of objectives, activity and strategizing research work. Design of timeline for work plan (Gnatt Chart etc), Grant Writing Guidelines	4
7	Experimental Research Inventory Management, Material Management Learning required skills for research, Documentation and lab notebook guidelines, Safety aspects in chemical/biological research	3
8	Methods and Tools used in Research: Qualitative studies; Quantitative studies; Simple data organization; Descriptive data analysis; Limitations and sources of error; Inquiries in form of Questionnaire, Opinionnaire or by interview; Statistical analysis of data	4

	including Variance, Standard deviation, Students 't' test and Analysis of variance (ANOVA), Correlation data and its interpretation, Computer data analysis	
9	Scientific Writing Skeleton of research paper, author guidelines, good writing skills, importance of discussion, Macro-level discussion. Structure of the documents. General issues of presentability. Micro-level discussion. Stylistic issues. Examples of bad and good writings.	3
10	Publishing and Reviewing Publication process, How to publish papers, where to submit, Review process and reacting to a review report Reviewing scientific papers	3
11	Scientific Norms and Conventions Authorship. Plagiarism. Simultaneous submissions. Reviewing norms. Referring to other papers. Use of data. Collaborative Research Work	2
	Total	**30**
List of Textbooks/ Reference Books		
1	Menzel, D.; Writing a Technical Paper; McGraw-Hill, United States (1961).	
2	Best, J. W., Kahn, J. V., Jha, A. K.; Research in Education; 10th ed.; Pearson, New Delhi, India (2005)	
3	Davis R. M.; Thesis Projects in Science and Engineering: A Complete Guide from Problem Selection to Final Presentation; St. Martin's Press, (1980).	
4	Anderson, J., Durston, B. H., Poole, M. E.; Thesis and Assignment Writing; John Wiley, United States (1970).	
5	Menzel, D.; Writing a Technical Paper; McGraw-Hill, United States (1961).	
6	Brown, L.; Effective Business Report Writing ; Prentice-Hall, United States (1973).	
7	WIPO Intellectual Property Handbook; WIPO Publication (2004).	
8	Carter, M.; Designing Science Presentations: A Visual Guide to Figures, Papers, Slides, Posters, and More; Academic Press, London (2013).	
9	Ranganathan, S. R.; Documentation : Genesis and Development; Ess Ess Publications, India (2006).	
Course Outcomes (students will be able to….)		
CO1	Understand the basic concepts of research and the components therein, formally	K2+P2
CO2	Understand and appreciate the significance of statistics in Chemical Technology	K3+P2
CO3	Understand and apply importance of literature survey in research design	K4+P3
CO4	Understand an in-depth knowledge on the documentation in research	K5+P3
CO5	Evaluate importance of various parts of a research report/paper/thesis in presentation of research results	K4+P3
CO6	Prepare and Deliver a model research presentation	K5+P3
CO7	Understand the significance of various types of IPRs in research	K3+P3
CO8	Create a model research project	K6+P4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	2	2	2	2	2	2	3
CO2	2	2	2	2	2	2	2	2	2	2	1	3
CO3	2	3	1	3	2	2	3	2	2	2	2	2
CO4	3	2	2	3	2	2	3	3	2	2	2	2
CO5	2	2	2	3	2	2	3	2	2	2	1	2
CO6	2	2	2	3	2	2	3	2	2	2	2	3

CO7	3	2	3	3	2	2	3	2	2	2	2	2
CO8	2	2	2	3	2	2	3	2	2	2	2	2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	2
CO2	2	1	2	2	1
CO3	2	2	3	2	2
CO4	2	2	2	2	2
CO5	2	1	2	2	1
CO6	2	3	2	3	2
CO7	2	3	2	3	2
CO8	2	3	2	3	2

RM-II	**Course Code:** DYT1201	**Course Title:** Design and Analysis of Experiments (Research Methodology – II)	**Credits =2**		
			L	**T**	**P**
	Semester: VII	**Total contact hours: 45**	**1**	**0**	**2**

List of Prerequisite Courses

Engineering Mathematics (MAT1301), Process Calculations (CEP1720)

List of Courses where this course will be prerequisite

This course is required for graduating students to function effectively in Industry, Academia and other professional spheres. Project-II (DYP1211).

Description of relevance of this course in the B. Tech. Program

Modern day manufacturing activities and R&D activities need decisions taken with a scientific rigor and should be well-supported by 'statistics'. Chemical Technologist graduates who will serve industry as well as postgraduate research students who will serve industry, R&D organizations, or academic research should have a reasonably good background of statistical decision making. This also involves extraction of meaningful data from well-designed minimal number of experiments at the lowest possible material costs. This course will also help the students in all domains of their life by imparting them a vision for critical appraisal and analysis of data.

	Course Contents (Topics and subtopics)	**Required Hours**
1	Fundamental principles of classical design of experiments Strategy of Experimentation, Typical applications of Experimental design, Basic Principles, Guidelines for Designing Experiments.	4
2	Review of Probability and basic statistical inference: Concepts of random variable, probability, density function cumulative distribution function. Sample and population, Measure of Central tendency; Mean median and mode, Measures of Variability, Concept of confidence level. Statistical Distributions: Normal, Log Normal & Weibull distributions, Hypothesis testing.	3
3	Experiments with a Single Factor: The Analysis of Variance Fixed effect model and Random effect model, Model adequacy checking, Contrasts, Orthogonal contrasts, Regression Models and ANOVA, Violation of Normality Assumption: Kruskal-Wallis test. Randomized block designs, Latin square designs, Balanced Incomplete Block Designs	6
4	Factorial designs: Definition, Estimating model parameters, Fitting response curves and surfaces.	3
5	The 2^k Factorial Design, Blocking and Confounding in the 2k Factorial Design; Focus of 2^2 and 2^3 designs, Blocking and Confounding in the 2^k Factorial Design.	6
6	Plackett Burman methods, Central Composite Design (CCD)	3
7	Descriptive Statistics, Probability Distribution and testing of Hypothesis using R	4

8	Regression techniques, diagnostic checks, ANOVA using R and implementation of contrasts.	4
9	Construction of Balanced Incomplete Block Designs and data analysis using R	4
10	Analysis of factorial designs using R, understanding output and interpretation.	4
11	Factorial designs, Data analysis and interpretation.	4
	Total	**45**
List of Textbooks/ Reference Books		
1	Douglas C. Montgomery, Design and Analysis of Experiments, 8th Edition, John Wiley & Sons, Inc. 2013	
2	Box, G. E., Hunter, W.G., Hunter, J.S., Hunter, W.G., Statistics for Experimenters: Design, Innovation, and Discovery, 2nd Edition, Wiley, 2005.	
3	John Lawson, Design and Analysis of Experiments with R, CRC Press, 2015	
4	Dieter Rasch, Jürgen Pilz, Rob Verdooren, Albrecht GebhardtOptimal Experimental Designs with R. CRC Press, 2011.	
5	José Unpingco, Python for Probability, Statistics, and Machine Learning, Springer, 2019	
6	Response Surface Methodology: Process and Product Optimization using Designed Experiments: R. H. Myers, D. C. Montgomery.	
7	Introduction to Statistical Quality Control: D. C. Montgomery.	
8	Design of Experiments in Chemical Engineering: Živorad R. Lazić.	
Course Outcomes (students will be able to….)		
CO1	Students should be able to understand basic principles of design of experiments.	K3
CO2	Students should be able to perform statistical analysis of single experiments and do post hoc analysis.	K4
CO3	Students should be able to conduct experiment and analyse the data using statistical methods.	K5
CO4	Students should be able to choose an appropriate design given the research problem.	K4
CO5	Students should be able to perform statistical analysis of different designs using R and interpret the results.	K5
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	2	0	3	3	3	3	3	3	1
CO2	3	2	2	2	2	3	3	3	1	2	3	2
CO3	3	3	2	2	1	1	3	3	3	3	3	2
CO4	3	3	2	2	2	3	0	2	3	3	3	2
CO5	3	2	2	0	2	3	3	3	1	3	0	2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	2	2
CO2	2	1	1	2	1
CO3	2	2	3	2	2
CO4	2	2	3	2	2
CO5	2	1	1	2	1

Project	**Course Code: DYP1191**	**Course Title: Project -I**	**Credits =4**		
			L	**T**	**P**
	Semester: VII	**Total contact hours: 120**	**0**	**0**	**8**
List of Prerequisite Courses					

Communication Skills (HUP1110B)		
List of Courses where this course will be prerequisite		
Project -II (DYP1211)		
Description of relevance of this course in the B. Tech. Program		
The course is designed to help students develop a skill-set for solving a research problem related to Dyestuff Sciences and Technology. The course presents an opportunity to the students for fine-tuning their scientific communication skills, oral as well as written.		
Course Contents (Topics and subtopics)		**Required Hours**
1	a) The Teachers will communicate various research topics of potential interest to the Dyestuff Sciences and Technology field to all the students based on the interest and facilities available. b) Each student, based on his/her interest and merit (CGPA) till Semester-V/VI and is allotted a supervisor. c) Student and Supervisor then selects the research topic The work involves detailed review of the literature, formulation of research project, hypothesis, objectives, methodology, and possible expected outcomes, planning for experimentation, experimental trials, data generation and analysis. d) Finally, the student will compile the report as per the communicated format and then present in front of the internal faculty Evaluators within the DSCT. e) Ideally student should start initial experiments by end of this semester.	120
	Total	**120**
List of Textbooks/ Reference Books		
1	Relevant research articles, patents, review articles, conference proceeding, book chapters and books	
Course Outcomes (students will be able to….)		
CO1	Develop critical thinking to identify the research gap for the project	K5+P4
CO2	Formulate a scientific question and approach to solve it	K5+P4
CO3	Plan the experimental methodology for the project	K5+P4
CO4	Develop skills to communicate the research plan effectively	K6+P4
CO5	Develop skills for writing a scientific document on the research work	K6+P4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	2	3	1	2	2	3	1	2	2	2
CO2	2	3	2	2	1	2	2	3	1	2	2	2
CO3	3	2	2	2	1	2	2	3	1	2	2	2
CO4	2	1	3	2	1	2	2	3	1	2	2	2
CO5	1	2	2	1	1	2	2	3	1	2	2	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	1	2	1
CO2	2	3	1	2	1
CO3	2	2	1	2	1
CO4	2	3	1	2	1
CO5	2	2	1	2	1

PCC	Course Code: DYP1201	Course Title: Pr-8: Lab-8: Synthesis, Analysis and Applications of Optical Brighteners	Credits = 2		
			L	T	P
	Semester: VII	Total Contact Hours: 60	0	0	4

List of Prerequisite Courses
HSC (Science); A Primer on Technology of Intermediates and Dyestuffs (DYT1011); Chromatographic Methods and Analysis (DYP1121)
List of Courses where this course will be prerequisite
Project-II (DYP1211)
Description of relevance of this course in the B. Tech. Program
This course will familiarize the students with synthesis, analysis & applications of various optical brighteners

	Course Contents (Topics and Subtopics)	Required Hours
1	Triazole based optical brighteners	15
2	DASDA & Coumarin based optical brighteners	15
3	Merwyn Arylation of Cinnamic Acid	15
4	Evaluation of Whiteness Index	15
	Total	**60**

List of Textbooks/Reference Books	
1	Fundamental Processes Of Dye Chemistry by Hans Eduard Fierz-David And Louis Blangey

Course Outcomes (Students will be able to…..)		
CO1	*Design* the synthetic route for the preparation of dyes and intermediates	K3+P4
CO2	*Conduct* experiments in the lab independently for the synthesis of dyes, intermediates and optical brighteners	K3+P3
CO3	*Execute* the process with utmost efficiency and precession	K3+P4
CO4	*Evaluate* the purity, and characterize the products via instrumental methods	K5+P4
CO5	*Apply* of the synthesized products for diverse uses	K4+P4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	3	3	1	3	1	3	2
CO2	3	3	3	3	3	3	2	0	3	1	3	2
CO3	3	3	3	3	3	3	2	0	3	1	3	3
CO4	3	2	2	3	3	2	1	2	3	1	3	1
CO5	3	3	3	3	3	3	3	1	3	1	3	2

Mapping of Course Outcomes (COs) with Specific Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	2	1
CO2	2	2	2	2	1
CO3	2	2	2	2	2
CO4	2	2	3	3	1
CO5	2	2	2	2	1

FINAL YEAR: SEMESTER – VIII

PCC	Course Code: DYT1211	Course Title: SPL-15: Applications of Organic Colorants	Credits = 3		
			L	T	P

	Semester: VIII	Total Contact Hours: 45	5	1	0

List of Prerequisite Courses

HSC (Science); A Primer on Technology of Intermediates and Dyestuffs (DYT1011); High Performance Pigments (DYT1151)

List of Courses where this course will be prerequisite

Pr 9: Lab-9: Formulation and Functional Applications of Colorants (DYP1221)

Description of relevance of this course in the B. Tech. Program

The students will be introduced to the concepts of functional organic colorants and their specific applications as well as will be exposed to the different classes of functional dyes and colorants.

	Course Contents (Topics and Subtopics)	Required Hours
1	Introduction to functional dyes. Indicator dyes, dyes used in other analytical techniques, laser dyes, liquid crystal dyes,	**10**
2	Dyes in electrophotography	**10**
3	Dyes for thermal printing	**05**
4	Dyes used in light harvesting devices like solar cells and other related uses, holography, Imaging	**05**
5	Non-linear optical properties of dyes and infrared absorbing dyes	**05**
6	Quasi aromatic fluorescent compounds	**05**
7	Colorants for Photodynamic theory	**05**
	Total	**45**

List of Textbooks/Reference Books

1	Advances in Color Chemistry – Vol I, Peters A. T.
2	Advances in Color Chemistry – Vol II, Peters A. T.
3	Non-Textile Dyes, Freeman H. S.
4	Coloring of Plastics: Fundamentals by Robert A. Charvat John Wiley & Sons, 11-Mar-2005
5	Coloring of plastics: theory and practice by M.Ahmad Van Nostrand Reinhold, 1979

Course Outcomes (Students will be able to…..)

CO1	Grasp broad idea about functional applications of dyes	K2
CO2	Understand underlying properties for their application in commercial product	K2
CO3	Know various colorants based on specific molecule engineering	K2
CO4	Apply the knowledge in planning the synthesis of functional dyes	K3
CO5	Design functional dyes based on the specific role	K4

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	1	1	2	0	1	1	2	0
CO2	2	2	2	2	1	1	2	1	1	1	2	0
CO3	2	3	2	2	1	2	2	0	1	1	2	0
CO4	2	2	2	2	2	2	3	1	2	2	2	2
CO5	3	3	3	3	2	2	3	1	2	2	2	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	1
CO2	2	2	3	2	1
CO3	2	2	3	2	1
CO4	3	2	2	3	1
CO5	2	2	2	2	2

PCC	Course Code: DYP1211	Course Title: Project – II (Experiments)	Credits = 3		
			L	T	P
	Semester: VIII	Total contact hours: 120	0	0	16

List of Prerequisite Courses
All Dyestuff subjects
List of Courses where this course will be prerequisite
Professional Career and future academic research
Description of relevance of this course in the B. Tech. Program
The course is designed to help students develop a skill-set for solving a research problem related to Dyestuff Sciences and Technology. The course presents an opportunity to the students for fine-tuning their scientific communication skills, oral as well as written.

	Course Contents (Topics and subtopics)	Required Hours
1	a) The topic of the research with clearly defined Objectives and Hypotheses should be explored systematically based on the initial experiments carried out in earlier semester, in a scientifically planned rational set of experiments under the supervision of guide. b) Students should have actual experimental data collected on the chosen research topic.	100
2	a) Oral presentation of the proposed research work with data generated during actual laboratory work along with computational studies, if any, targeted towards fulfilling the objectives. b) The outcome is submitted in the form of a report and Viva-voce examination will be conducted and will be evaluated by both internal and external subject experts.	20
	Total	**120**

List of Textbooks/ Reference Books	
1	Relevant review articles, research papers, patents, book chapter, books, etc.

Course Outcomes (students will be able to….)		
CO1	Perform experiments & troubleshoot to generate reliable data	K4+P5
CO2	Apply different statistical tools for scientific data analysis	K5+P5
CO3	Evaluate critically the experimental data and draw meaningful inferences	K6+P5
CO4	Develop skills to communicate the research outcome effectively	K6+P5
CO5	Develop skills for writing a complete document on the project work	K6+P5

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	2	3	2	2	2	3
CO2	3	3	3	3	3	3	2	3	2	2	2	3
CO3	3	3	3	3	3	3	3	3	2	3	2	3
CO4	3	3	3	3	3	3	3	3	2	2	2	3
CO5	3	3	3	3	3	3	3	3	2	2	2	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3

CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

PEC	Course Code: DYP1221	Course Title: **Pr-9: Lab-9: Formulation and Functional Applications of Colorants**	Credits = 2		
			L	T	P
	Semester: VIII	Total Contact Hours: 60	0	0	4

List of Prerequisite Courses

HSC (Science); Application of Colorants (DYP1171); Formulation Technology in Colorants (DYT1221); Applications of Organic Colorants (DYT1211)

List of Courses where this course will be prerequisite

Nil

Description of relevance of this course in the B. Tech. Program

This course will familiarize the students with the formulation & applications of various colorants.

	Course Contents (Topics and Subtopics)	Required Hours
1	Formulation, Analysis & Applications of Colorants for any of the following categories: A) Foods B) Inks C) Paints & Coatings & Polymers/Plastics D) Inkjet printing E) CD-DVDs F) Security colorants G) Lasers H) Liquid crystals I) Electrophotography J) Thermal printing K) Solar cells L) Holography M) Imaging N) Analytical Techniques O) IR applications P) Fluorescent applications O) Cosmetic applications	60
	Total	**60**

List of Textbooks/Reference Books

1	Fundamental Processes Of Dye Chemistry by Hans Eduard Fierz-David And Louis Blangey

Course Outcomes (Students will be able to…..)

CO1	*Design* the synthetic route for the preparation of colorants	K3+P4
CO2	*Conduct* experiments in the lab independently for the synthesis of various colorants	K3+P3
CO3	*Execute* the process with utmost efficiency and precession	K3+P4
CO4	*Evaluate* the purity, and characterize the products via instrumental methods	K5+P4
CO5	*Apply* of the synthesized products for diverse uses	K4+P4

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	3	3	3	3	1	3	3	1	3	1	3	2
CO2	3	3	3	3	3	3	2	0	3	1	3	2
CO3	3	3	3	3	3	3	2	0	3	1	3	3
CO4	3	2	2	3	3	2	1	2	3	1	3	1
CO5	3	3	3	3	3	3	3	1	3	1	3	2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	2
CO2	3	2	1	3	1
CO3	2	1	2	2	1
CO4	3	2	2	1	1
CO5	2	2	2	2	1

OJT	**Course Code:** **DYP1231**	**Course Title:** **Internship with Industry**	**Credits = 12**		
			L	**T**	**P**
	Semester: VIII	**Total contact hours: 12-16 weeks**	**0**	**0**	**0**

List of Prerequisite Courses

All Special subjects and practical

List of Courses where this course will be prerequisite

Industrial career and Academic research

Description of relevance of this course in the B. Tech. Program

The course is designed to –

1. Develop a systematic thinking about an industrial problem;

2. Develop skills for communication, networking, personal grooming & professional conduct within an industrial environment, and

3. Develop the attitude for individual and teamwork.

	Course Contents (Topics and subtopics)	**Required Hours (weeks)**
1	In the **Eighth semester**, every student will have to undergo an internship and/or On Job Training. The Internship would be of **12 credits**. 1. The internship would be assigned to the student by the Departmental Internship Coordinator, with the approval of Head of the Department. 2. The total duration of the internship would be for a period equivalent to 12 Calendar weeks. The internship may be completed in one or more organizations as described below. 3. The internship could be of the following forms: 4. Industrial internship in a company (within India or Abroad) involved in R&D / Project design / manufacturing (QA/QC/Plant Engineering/Stores and Purchase) / marketing / finance / consultancy / Technical services / Engineering/Technology / Projects, etc. 5. At the end of the internship, each student will submit a written report based on the work carried out during the Internship. The report will be countersigned by the Supervisor from Industry / Institute as the case may be. 6. Performance of the student will be assessed based on the written report and a presentation to a committee consisting of two faculty members from the Department of Speciality Chemicals Technology. 7. Students will be assigned a grade based on the written report and a presentation; evaluated by a committee of faculty members.	12

	8. Feedback will be taken from Industry mentors and this will used while assigning the grades.	
	Total	**12 Weeks**

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

E. Scheme of Evaluation of Internship with Industry (SEMESTER – VIII)

PROGRAM ELECTIVES

PEC	Course Code: DYT1081	Course Title: SPL8: Quantum Mechanics for Color Chemists	Credits = 4		
			L	T	P
	Semester: V	Total Contact Hours: 60	3	1	0

List of Prerequisite Courses
HSC (Science); Organic Chemistry (CHT1407)
List of Courses where this course will be prerequisite
All courses involving color
Description of relevance of this course in the B. Tech. Program
To make the students understand computational material science in general and computational color chemistry. To make them understand the physical basis of color of organic molecules of industrial importance. To enable them to analyze the early empirical theories of color and chemical constitution relationships of industrial dyes in the light of quantum chemistry. To develop in them capacity to understand proper selection of computational strategy for understanding the properties of commercial important organic colorants.

	Course Contents (Topics and Subtopics)	Required Hours
1	Evolution of computational material science. Early qualitative theories of color and chemical constitution like theory of unsaturation, quinonoid theory. Manifestation of color as an outcome of interaction between electromagnetic radiation and matter.	04
2	Brief revision of quantum mechanical concepts with special reference to one electron systems. Particle in one-dimensional box treatment and its application to polyene and cyanine dyes. Particle in a ring, sphere and application in understanding the application in the absorption spectra of aromatic hydrocarbons.	07
3	Beer-Lambert law. Quantitative treatment of strength of absorption of electromagnetic radiation. Absorption cross section. Transition dipole and transition dipole moment. Solvatochromism in colorants and its application to understand the excited state properties of dyes.	08
4	Problems associated with the many electron systems. Hartree-Fock formalism for many electron systems.	08
5	Quantum mechanical concepts relevant to the understanding of bonding in organic colorants. Resonance theory, valence bond descriptions. Bond Length Alternation, Bond Order Alternation, Aromaticity and quantum mechanical descriptors of aromaticity.	06

6	Semiempirical methods of calculation of absorption spectra. Configuration Interaction Singles. Hartree-Fock method in Time Dependent Domain. Density Functional Theory and its Time Dependent formalism. Post- HartreeFock methods.	12
Total		**45**

List of Textbooks/Reference Books

1	J. Griffiths, Colour and Constitution of Organic Molecules, Academic Press, London (1976)
2	J. Fabian, H. Hartmann, Light Absorption of Organic Colorants, Springer-Verlag, Berlin 1980
3	S.M. Bachrach, Computational Organic Chemistry, Wiley, 2014
4	W.Koch, Chemist's guide to Density Functional Theory, Wiley-VCH, 2008

Course Outcomes (Students will be able to…..)

CO1	Understand the basics of color and chemical constitution	K2
CO2	Acquire basics of computational material science knowledge	K2
CO3	*Analyze* the various quantum mechanical tools to understand color of dyes	K2
CO4	*Know* the various methodologies in computational spectroscopy	K2

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	3	2	1	1	0	1	1	1	3
CO2	3	3	1	3	2	1	1	0	1	1	1	3
CO3	3	3	2	3	2	2	1	1	1	1	2	3
CO4	3	3	2	3	2	2	1	1	1	1	1	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	1
CO2	3	2	2	2	1
CO3	2	2	3	2	1
CO4	2	2	2	2	1

PEC	**Course Code:** DYT1121	**Course Title:** SPL11: Chemistry and Technology of Pigments	**Credits = 4**		
			L	**T**	**P**
	Semester: VI	**Total contact hours: 60**	3	1	0

List of Prerequisite Courses

HSC (Science); Industrial Chemistry (CHT1408)

List of Courses where this course will be prerequisite

All courses involving pigments

Description of relevance of this course in the B. Tech. Program

Students will be taught about the classification, chemistry and technology of various pigments

	Course Contents (Topics and subtopics)	**Reqd. hours**
1	Introduction to pigments, Colour and physical constitution, optical properties of Organic and inorganic pigments, Introduction to general method of determination of inorganic pigment.	5
2	Classification and general discussion about different classes of organic pigments: Azo pigments, Azo pigments, Benzimidazolone pigments, disazo condensation pigments, metal complex pigments, polycyclic pigments, phthalocyanine pigments, Anthraquinone pigments, heterocyclic pigments Classification and general discussion about different classes of inorganic pigments: White Pigments based on Titanium Oxide, Zinc oxide, and Zinc Sulfide, Various colored pigments on metal oxides and hydroxides; Black pigments and Inorganic pigments with special properties for examples	5

	Magnetic pigment, Luminescent pigments, Transparent pigments, Electroluminescent pigments, Special effect pigments, etc	
3	Chemical and physical characterization of pigments: Hue, Crystal modification and crystal structure, Tinctorial strength, Light fastness and weather fastness, Solvent and migration fastness, specific surface area, Particle size distribution, Polymorphism, and crystallinity	5
4	Application properties of pigments: Coloristic property, Color depth, Tinctorial strength, Hiding power, Transparency, Fastness properties, Migration properties, Blooming, Bleeding, Over pigmentation	5
5	Pigment dispersion technology, Pigment dispersion kinetics and thermodynamics, Dispersion and critical pigment volume concentration, Surface modification of pigments	5
6	Pigment finishing and standardization, Newer Technologies of pigment processing. Latent Pigment Technology, Flush pigments, Pigment evaluation techniques and equipment.	5
7	Azo pigments: Classification of azo pigments, starting material synthesis, Important intermediates, Synthesis of azo pigments, Methods of diazotization and coupling, Finishing of azo pigments, Filtration, drying and milling techniques, Production units for azo pigments manufacture, Mono azo yellow and orange pigments, Chemistry and manufacturing technologies of lake pigments, dis azo pigments, Diarylide yellow pigments, bisacetoacetarylide pigments, beta-naphthol pigments, naphthol AS pigments, BONA pigment lakes, Metal complex pigments	15
8	White Pigments based on Titanium Oxide, Zinc oxide, and Zinc Sulfide; properties, production, raw materials, application in commercial products, and toxicology	5
9	Natural source and commercial production of black pigments; Chemical and Physical properties of black pigments; their application in Paints, Plastics, and Printing inks; Detailed Safety issues and, Toxicology	5
10	Inorganic pigments with special properties for examples Magnetic pigment, Luminescent pigments, Transparent pigments, Electroluminescent pigments, Special effect pigments, etc.	5
	Total	**60**
List of Text Books		
1	Chemistry of Synthetic Dyes and Pigments, Lubs H. A., Robert E Krieger Publishing	
2	Industrial Inorganic Pigments Edited by G. Buxbaum and G. Pfaff, Wiley VCH	
3	Chemistry of Synthetic Dyes – Vol II, Venkataraman K., Academic Press, New York, 1952	
4	Industrial Organic Pigments – Production, Properties, Applications, Herbst W. and Hunger K., VCH Verlag, Weinheim, 1997.	
5	High Performance Pigments, Smith H. M.	
List of Additional Reading Material / Reference Books		
1	The Colour Science of Dyes and Pigments, R. McLaren Bristol, Adam Hilger Ltd., 1983	
2	Color Chemistry –Synthesis, Properties and Applications of Dyes and Pigments, Zollinger H., 2nd ed., Weinheim – VCH, 1991	

CO1	*Differentiate* between dyes and pigments	K2
CO2	*Conceptualize* the basic pigmentary properties like hue, tinctorial strength, blooming, bleeding, stability, optical properties, polymorphism, etc.	K2
CO3	*Classify* the pigments based on chemical constitution and color	K3
CO4	*Correlate* and predict various application properties of pigments	K3
CO5	*Design* the synthesis and manufacturing technology of pigments	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	2	1	3	1	2	1	1	3	1
CO2	2	3	2	3	2	2	2	2	1	1	3	1
CO3	3	2	2	3	2	2	2	2	1	1	2	1
CO4	3	3	3	2	2	3	3	3	1	1	3	2

CO5	3	3	2	3	2	3	2	3	1	1	3	1

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	1
CO2	3	2	2	3	1
CO3	2	3	3	2	1
CO4	3	3	2	2	2
CO5	2	2	3	2	1

PEC	**Course Code: DYT1171**	**Course Title** **SPL-15: Colorants in Organic Electronics**	**Credits = 3**		
			L	**T**	**P**
	Semester: VII	**Total Contact Hours: 45**	**2**	**1**	**0**

List of Prerequisite Courses

HSC (Science); Electrical Engineering and Electronics (GET1125)

List of Courses where this course will be prerequisite

Nil

Description of relevance of this course in the B. Tech. Program

Students will be able to understand the basics characteristic of colorants for the applications in organic electronics

	Course Contents (Topics and Subtopics)	**Required Hours**
1	Materials' Foundations: Introduction. Electronic Structure: Atomic Structure, Elections in Atom, Filling of Orbitals, The periodic table. Chemical Bonding: Bonding Principles, Ionic Bond, Covalent Bond, Metallic Bond, Van der Waals Bonding, Hydrogen Bonding. Bonding in Organic Compounds: Hybridized Orbitals, Isomers, Double and Triple Bonds	06
2	Electrical Conductivity: Classical Theory, Electrical Conductivity, Charge Carrier Mobility, Fermi Energy Bands in Solids, Conductors, Semiconductors and Insulators, Electrons and Holes, Intrinsic and Extrinsic Conduction, Organic Compounds, Band Structure , Doping, Solitons, Polarons and Bipolarons.	06
3	Functional Groups, Aromatic Compounds, Conductive Polymers, Charge-Transfer Complexes, Buckyballs and Nanotubes, Fullerenes, Carbon Nanotubes	06
4	Tools for Molecular Electronics: Direct Imaging, X-ray Reflection, Electron Diffraction, Raman Scattering Surface Analytical Techniques, Scanning Probe Microscopies, Film Thickness Measurements, Infrared Spectroscopy, NMR Spectroscopy, Mass Spectroscopy	06
5	Applications: Dye sensitized solar cell, Organic light emitting diode, Organic transistor, Flexible Electronics, etc.	06
	Total	**30**

List of Textbooks/Reference Books

1	*Molecular Electronics from principles to practice*, Michael C. Petty, John Wiley & Sons Ltd., 2007
2	Organic Electronics materials, manufacturing, and applications, Hagen Klauk, Whiley-VCH, 2006

Course Outcomes (Students will be able to…..)

CO1	Ability to understand the fundamental knowledge on basics organic molecules	K2
CO2	Ability to understand and explain the physical and chemical properties of organic molecules	K3
CO3	Ability to understand the correlation organic molecules and electronic applications	K2
CO4	Ability to understand and analyze the role of organic materials and it's application, properties	K4
CO5	Ability to understand the fundamental application of organic molecules	K5

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	2	3	2	2	2	1	2	2	2	2	2	2
CO2	2	3	2	2	2	3	1	2	2	1	2	2
CO3	3	2	2	2	3	3	2	1	2	2	2	1
CO4	2	3	1	3	2	2	1	2	2	1	2	1
CO5	2	2	3	3	3	3	2	1	2	2	1	2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	3
CO2	2	3	2	2	2
CO3	3	2	2	2	2
CO4	2	2	2	2	2
CO5	3	2	2	2	2

PEC	**Course Code: DYT1181**	**Course Title** **SPL-16: Technology of Biosensors**	**Credits = 2**		
			L	**T**	**P**
	Semester: VII	**Total Contact Hours: 30**	**1**	**1**	**0**

List of Prerequisite Courses

HSC (Science);

List of Courses where this course will be prerequisite

Nil

Description of relevance of this course in the B. Tech. Program

To introduce various advance concepts of sensors used for biological system

	Course Contents (Topics and Subtopics)	**Required Hours**
1	General concept sensing and elements of biosensing	06
2	Antibodies and other recognition elements	06
3	Modes of recognition	06
4	Fluorescence based sensing	06
5	Fluorescent dyes in biosensing	06
	Total	**30**

List of Textbooks/Reference Books

1	Biosensors and Biodetection – Ed - Avraham Rasooly and Keith E. Herold, Humana Press 2008
2	Biosensors for medical applications – Edited by Seamus Higson, Woodhead Publishing Limited, 2012
3	Molecular Biosensor, Bernard Valeur, Wiley VCH, 2002

Course Outcomes (Students will be able to…..)

CO1	Comprehend biosensing as a useful domain in bio-analytical techniques	K2
CO2	Comprehend the components of a biosensor	K2
CO3	Learn the recognition elements – antibodies, diabodies, affibodies, affinity proteins, aptamers	K2
CO4	Able to design a biosensor	K3
CO5	Propose a biosensor design for any specific analyte	K4

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	3	2	3	1	0	1	3
CO2	2	2	2	2	2	2	2	2	2	1	1	2
CO3	2	3	2	3	2	2	2	0	2	1	0	2

CO4	3	3	3	3	3	2	2	2	2	3	2	3
CO5	3	3	3	3	3	3	3	2	2	3	2	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	2
CO2	2	1	2	2	2
CO3	3	2	2	2	2
CO4	2	2	2	2	2
CO5	2	2	2	2	2

HONORS

PCC	Course Code: DYT1091	Course Title: Honors Course-1: Metal Complex Colorants	Credits = 4		
			L	T	P
	Semester: V	Total Contact Hours: 60	3	1	0

List of Prerequisite Courses
HSC (Science);
List of Courses where this course will be prerequisite
Applications of Organic Colorants (DYT1211)
Description of relevance of this course in the B. Tech. Program
To make the students understand about Metal Complex Colorants

	Course Contents (Topics and Subtopics)	Required Hours
1	Types of metal complex dyes – premealllized, afterchrome and metachrome dyes. Nuclear, and peripheral metal complexes. 1:1 and 1:2 metal complexes	4
2	Nature of colored ligands and their occurrence in colorants. Techniques of metal complexation – oxidative, demethylative and hydrolytic metal complexation	4
3	Modification properties on metal complexation	4
4	Absorption characteristics of metal complex dyes	4
5	Typical intermediates and their synthesis	6
6	Mordant dyes	4
7	Acid mordant dyes	4
8	Azomethine colorants	4
9	Azo metal complexes	12
10	Copper phthalocyanine and derivatives	6
11	Metal complex reactive dyes	4
12	Metal complexes as sensitizers in DSSC	4
	Total	45

List of Textbooks/Reference Books	
1	The Chemistry of Synthetic Dyes – Vol I, Venkataraman K., Academic Press
2	The Chemistry of Synthetic Dyes – Vol II, Venkataraman K., Academic Press
3	The Chemistry of Synthetic Dyes – Vol III, Venkataraman K., Academic Press
4	The Chemistry of Synthetic Dyes and Pigments, Lubs H. A., Robert E. Krieger Publishing Co

Course Outcomes (Students will be able to…..)		
CO1	Explain and define the classes of metal complex dyes	K2
CO2	Understand the variety and chemistry of metal complex dyes and their application	K2

CO3	Overview of recent trends in this field of metal complex dyes	K2
CO4	Differentiate the techniques of for synthesis of different metal complex dyes	K2
CO5	Design the synthesis of novel metal complex based dyes	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	0	0	0	0	0	0	3	0
CO2	2	2	2	2	0	0	0	0	0	0	3	0
CO3	2	3	2	3	1	1	1	1	0	0	3	0
CO4	2	3	2	3	1	1	1	1	1	1	3	1
CO5	3	3	3	3	2	2	2	1	2	2	3	2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	2
CO2	2	2	2	2	2
CO3	3	2	2	2	2
CO4	2	2	2	2	2
CO5	2	2	2	2	2

PCC	**Course Code:** **DYT1141**	**Course Title:** **Honors Course II: Near-IR Absorbing Dyes – Chemistry and Technology**	**Credits = 4**		
			L	**T**	**P**
	Semester: VI	**Total Contact Hours: 60**	**3**	**1**	**0**

List of Prerequisite Courses

HSC (Science);

List of Courses where this course will be prerequisite

Nil

Description of relevance of this course in the B. Tech. Program

To make the students understand about Near IR Absorbing Dyes

	Course Contents (Topics and Subtopics)	**Required Hours**
1	Creating red shift in absorption of dyes – general design strategies	5
2	Technological importance NIR lights and NIR dyes	6
3	NIR-absorbing and NIR-reflecting colorants	6
4	Cyanines	6
5	NIR-absorbing azo dyes	6
6	Mordant dyes	**6**
7	NIR absorbing xanthenes	**5**
8	NIR absorbing coumarins	**5**
9	BODIPY and aza-BODIPY dyes	**5**
10	NIR absorbing quinonoid dyes	**5**
11	ESIPT dyes	**5**
	Total	**60**

List of Textbooks/Reference Books

1	Near InfraRed Absorbing Dyes by Matsuoka

Course Outcomes (Students will be able to…..)

CO1	Explain and define the classes of near IR dyes	K2

CO2	Understand the variety and chemistry of near IR dyes and their application	K2
CO3	Overview of recent trends in this field of dyes	K2
CO4	Differentiate the techniques of for synthesis different near IR dyes	K2
CO5	Design the synthesis of novel near IR based dyes	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	0	0	0	0	0	0	3	0
CO2	2	2	2	2	0	0	0	0	0	0	3	0
CO3	2	3	2	3	1	1	1	1	0	0	3	0
CO4	2	3	2	3	1	1	1	1	1	1	3	1
CO5	3	3	3	3	2	2	2	1	2	2	3	2
	3	3	3	3	2	2	2	1	2	2	3	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	3	2
CO2	2	2	3	2	1
CO3	2	3	2	2	1
CO4	2	2	2	3	1
CO5	2	2	2	2	1

PCC	**Course Code:** **DYT1191**	**Course Title:** **Honors Course III: Case Studies in Colorants Industry**	**Credits = 4**		
			L	**T**	**P**
	Semester: VII	**Total Contact Hours: 60**	**3**	**1**	**0**

List of Prerequisite Courses

HSC (Science); High Performance Pigments (DYT1151); Chemistry and Technology of Fluorescent Colorants (DYT1161)

List of Courses where this course will be prerequisite

Nil

Description of relevance of this course in the B. Tech. Program

The students will be introduced to several practical aspects of the synthesis of dyestuff intermediates as well as dyes and pigments in the industry and the problem statements along with the solution will be discussed.

	Course Contents (Topics and Subtopics)	**Required Hours**
1	Practical Aspects of Nitration: The concentration of mixed acids, Importance of DVS Ratio, thumb rules for the commercial calculations of batches, Material of construction and its life cycle	10
2	Reduction in the dyestuff industry: Reagents used for reduction, Reaction conditions for different reagents, Comparisons of operating different reagents at industrial scale, Material of construction, shop-floor practices and safety measures	10
3	Case studies of the synthesis of Bromamine Acid, Synthesis of Bromamine acid laboratory scale and plant scale, Bromination commercial aspect, Sulfonation of Anthraquinones, Material of construction and safety protocols for using Bromine and strong acids.	10
4	Equipment sizing and material of construction, calculations for heat capacities of utilities, cost calculations and estimation of payback period for projects	10
5	Ammonolysis laboratory scale set up and scale up, ammonia generation and storage aspects, safety protocols for ammonolysis, industrial thumb rules for the ammonolysis	10

6	Reaction Mechanisms for all the processes described and their relevance in deciding parameters for arriving at the process. 1) Importance of Physical Organic Chemistry. 2) Reaction Thermodynamics and Kinetics. 3) Making choices during Process Design and Project implementation 4) Manufacturing practices followed with safety and hazop. 5) Effluent treatment.norms standard processes and practice. 6) Price of Reagents employed 7) Interdependence of all the parameters employed 8) Marketing and pricing. 9) Scale up and how to decide which parameters are important 10) Technology employed and its relevance with Development in other fields like Analysis, Material availability, Engineering progress , Locational factors.	10
	Total	**60**

List of Textbooks/Reference Books

1	*BIOS Reports*
2	*FIAT Reports*
3	*CIOS Reports*
4	*Organic Synthesis Collective Volumes I-V*
5	*Shreve's Chemical Process Industries by George T Austin*
6	Unit Processes in Organic Synthesis by Philip Groggins
7	*Chemical, Biochemical, and Engineering Thermodynamics by Stanley I Sandler*
8	*Marchs Advanced Organic Chemistry by Jerry March*

Course Outcomes (Students will be able to…..)

CO1	*Correlate* industry-oriented situations for synthesis or isolation of intermediates	K2
CO2	*Understand* practical aspects of selection of suitable methods and isolation techniques	K2
CO3	*Realize* the utility of the theoretical concepts in the practical situations	K2
CO4	*Formulate* strategies to solve the practical problem	K4
CO5	Assess the problem component and come up with a rational solution	K5

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	2	3	2	0	1	2	0
CO2	3	3	3	3	3	2	3	2	0	1	2	0
CO3	2	3	3	3	3	3	3	2	2	1	2	2
CO4	3	3	3	3	3	3	3	2	2	3	3	3
CO5	3	3	3	3	3	3	3	2	2	3	3	3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	3
CO2	2	2	2	2	2
CO3	3	2	2	3	2
CO4	2	3	2	2	2
CO5	2	2	3	2	3

PCC	**Course Code:**	**Course Title:**	**Credits = 3**		
	DYT1221	**Honors Course - IV - Formulation Technology in Colorants**	**L**	**T**	**P**
	Semester: VIII	**Total Contact Hours: 45**	**2**	**1**	**0**

List of Prerequisite Courses

HSC (Science);		
List of Courses where this course will be prerequisite		
Nil		
Description of relevance of this course in the B. Tech. Program		
To introduce various aspects of formulations to students		
	Course Contents (Topics and Subtopics)	**Required Hours**
1	Introduction to formulations, basics of formulations, types of formulation etc	**09**
2	Basics of formulations, types of formulation etc	**09**
2	Formulations in food dyes	**09**
3	Formulations in inks	**09**
4	Ingredients and parameters used for the formulation in, paints, other high tech applications of colorants including inkjet printing ink, CD-DVDs, security colorants etc.	**09**
	Total	**45**
List of Textbooks/Reference Books		
1	Coatings Formulation, An international textbook, Bodo Müller, Ulrich Poth; European Coatings Tech Files	
2	Printing Ink Formulations, Ernest W. Flick, Noyes Publications, 1985	
3	Chemical Formulation: An Overview of Surfactant Based Chemical Preparations Used in Everyday Life, Author: Anthony E Hargreaves	
4	Basics of Paint Technology part I and II, V. C. Malshe	
5	Perfumes and Flavours Technology Handbook, H. Panda	
6	Textbook of cosmetic formulations, Gaurav kumar Sharma	
Course Outcomes (Students will be able to…..)		
CO1	Define and state different terminologies related to fine chemicals	K2
CO2	Describe and explain the general requirements for specialty chemicals and their techniques and application procedures for formulations	K2
CO3	Classify and differentiate formulations based on application and importance	K2
CO4	Outline the importance of formulation in various compounds	K3
CO5	Justify and illustrate the involvement of green chemistry and advancement strategies	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	3	2	2	3	3	1	2	2	2	1	2
CO2	2	3	2	3	2	3	2	2	2	2	2	1
CO3	2	2	3	2	3	3	2	2	1	2	2	2
CO4	3	3	3	2	2	2	2	1	2	1	2	2
CO5	2	2	2	3	2	2	1	2	2	2	2	2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	2
CO2	2	2	3	2	1
CO3	3	3	2	2	1
CO4	2	2	2	2	1
CO5	3	2	2	3	1

PCC	**Course Code:** **DYT1231**	**Course Title:** **Honors Course – V** **Industrial Waste Management in Colorants Industry**	**Credits = 3**		
			L	**T**	**P**
	Semester: VIII	**Total Contact Hours: 45**	**2**	**1**	**0**

List of Prerequisite Courses		
HSC (Science); Industrial Chemistry (CHT1408); Environmental Science and Technology (HUT1206)		
List of Courses where this course will be prerequisite		
Nil		
Description of relevance of this course in the B. Tech. Program		
To introduce various existing processes and technology of waste management concepts.		
	Course Contents (Topics and Subtopics)	**Required Hours**
1	Waste – Characteristics, Types and Generation	**09**
2	Solid Waste Management – Creation of Resource. Recent Trends in Composting. Handling gaseous and particulate effluents	**09**
3	Recycling and Reuse – Plastics, Metals and Other Useful Materials Waste-to-Energy – The Recent Advances	**09**
4	Transition from Wastewater Treatment Plant (WWTP) to Water Resource Recovery Facility (WRRF)	**09**
5	Sustainability of Waste-to-Wealth Technologies Application of the Principles of Circular Economy	**09**
	Total	**45**
List of Textbooks/Reference Books		
1	Industrial Waste Water Treatment Paperback – 2008 by Patwardhan A.	
2	Industrial Wastewater Treatment, Recycling and Reuse 1st Edition - Authors: Vivek Ranade Vinay Bhandari	
3	A Handbook of Effluent Treatment Plants - Author: Mehjabin Shaikh	
4	Fundamentals of Biological Wastewater Treatment - Author(s): Prof. Dr.-Ing. Udo Wiesmann Dr.-Ing. In Su Choi Prof. Dr.-Ing. Eva-Maria Dombrowski	
5	Industrial Wastewater Treatment 1st Edition - J.D. Edwards	

Course Outcomes (Students will be able to…..)		
CO1	Identify the source of waste generation and identify them	K2
CO2	Strategize the waste management	K2
CO3	Choose waste treatment methodologies	K2
CO4	Able to evolve methods to reduce waste at source	K3
CO5	Give a layout of effluent treatment plant	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	2	2	3	3	3	2	2	2	2
CO2	2	2	2	2	2	3	3	3	1	2	2	2
CO3	2	3	2	2	1	1	3	3	2	2	2	2
CO4	3	3	2	2	2	3	0	2	2	1	1	2
CO5	3	2	2	0	2	2	2	2	1	2	0	2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	2	2	3
CO2	3	2	3	2	2
CO3	2	3	2	2	2
CO4	3	2	2	3	3

CO5	2	3	2	2	2