BANASTHALI VIDYAPITH

Bachelor of Technology (Chemical Engineering)

Curriculum Structure

First Semester Examination, December, 2020
Second Semester Examination, April/May, 2021
Third Semester Examination, December, 2021
Fourth Semester Examination, April/May, 2022
Fifth Semester Examination, December, 2022
Sixth Semester Examination, April/May, 2023
Seventh Semester Examination, December, 2023
Eighth Semester Examination, April/May, 2024

BANASTHALI VIDYAPITH
P.O. BANASTHALI VIDYAPITH
(Rajasthan)-304022

July, 2020

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No. F. 9-6/81-U.3

Government of India
Ministry of Education and Culture
(Department of Education)

New Delhi, the 25th October, 1983

N O T I F I C A T I O N

In exercise of the powers conferred by Section 3 of the University Grants Commission Act, 1956 (3 of 1956) the Central Government, on the advice of the Commission, hereby declare that Banasthali Vidyapith, P. O. Banasthali Vidyapith, (Rajasthan) shall be deemed to be a University for the purpose of the aforesaid Act.

Sd/-
(M. R. Kolhatkar)
Joint Secretary of the Government of India

N O T I C E

Changes in Bye-laws/Syllabi and Books may from time to time be made by amendment or remaking, and a Candidate shall, except in so far as the Vidyapith determines otherwise, comply with any change that applies to years she has not completed at the time of change.

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Programme Educational Objectives

- To develop latitude of effectiveness in applying chemical engineering principles in engineering practice or for advanced study in chemical engineering, medicine, law, business and social work.
- To develop longitude of not only opening careers in the branch of study as well as interdisciplinary and multidisciplinary fields such as pharmaceuticals, microelectronics, chemicals, polymers/ advanced materials, food processing, energy, biotechnology and environmental engineering.
- To develop altitude of professionalism to function effectively in the complex modern work environment, both as individuals as well as in team, with the ability to assume leadership roles and achieve understanding and appreciation of ethical behavior, social responsibility and diversity.

Programme Outcomes

Each graduate will be able to:-

- have an education that is supportive of a broad awareness of the diversity of the world and its cultures, and that provides an understanding of the impact of engineering practice in the global, economic, environmental, and societal context.
- demonstrate a working knowledge, including safety and environmental aspects, of material and energy balances applied to chemical processes; thermodynamics of physical and chemical equilibria; heat, mass, and momentum transport; chemical reaction engineering; continuous and stage wise separation operations; process dynamics and control; and chemical engineering design.
- have the ability to apply knowledge of mathematics, science and engineering to analyze and interpret data and design and conduct experiments safely, as well as the ability to design a process that meets desired specifications with consideration of environmental, safety, economic and ethical criteria.
- ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
- have the ability to communicate effectively in written, oral, and graphical forms as well as work as a member of multidisciplinary teams, and have an understanding of team leadership.
- have knowledge of contemporary issues and will recognize the need for and have the ability to engage in lifelong learning.
- To develop longitude of not only opening careers in the branch of study as well as interdisciplinary and multidisciplinary fields such as pharmaceuticals, microelectronics, chemicals, polymers/ advanced materials, food processing, energy, biotechnology and environmental engineering.

Curriculum Structure

Semester – I

Course	Code	Course Name	L	T	P	C*
BVF014/BVF011		सामान्य हिन्दी/General English	2	0	0	2
		Core Foundation Course-I	2	0	0	2
MATH	103/	Calculus/Linear Algebra	3	1	0	4
MATH	107					
PHY	101/	Applied Optics/Modern Physics	3	1	0	4
PHY	106					
CHEM	101/	Chemistry/Biology	3	1	0	4
BIO	101					
CHE	102/	Thermodynamics/Engineering Mechanics	3	1	0	4
PHY	109					
CS	109/	Computer Fundamentals and	4	0	0	4
EEE	101	Programming/Electrical Engineering				
CS	109L/	Computer Fundamentals and Programming	0	0	4	2
EEE	101L	Lab/Electrical Engineering Lab				
ENGG	101L/	Engineering Drawing and Graphics	0	0	6	3
ENGG	103L	Lab/Measurement Techniques Lab				
		Semester Total:	**20**	**4**	**10**	**29**

Semester – II

Course	Code	Course Name	L	T	P	C*
BVF011/BVF014		General English/ सामान्य हिन्दी	2	0	0	2
		Core Foundation Course-II	2	0	0	2
MATH	107/	Linear Algebra/Calculus	3	1	0	4
MATH	103					
PHY	106/	Modern Physics/Applied Optics	3	1	0	4
PHY	101					
BIO	101/	Biology/Chemistry	3	1	0	4
CHEM	101					
PHY	109/	Engineering Mechanics/Thermodynamics	3	1	0	4
CHE	102					
EEE	101/	Electrical Engineering/Computer	4	0	0	4
CS	109	Fundamentals and Programming				
EEE	101L/	Electrical Engineering Lab/Computer	0	0	4	2
CS	109L	Fundamentals and Programming Lab				
ENGG	103L/	Measurement Techniques Lab/Engineering	0	0	6	3
ENGG	101L	Drawing and Graphics Lab				
		Semester Total:	**20**	**4**	**10**	**29**

Semester – III

Course	Code	Course Name	L	T	P	C*
		Core Foundation Course-III	2	0	0	2
		Elective Foundation Course-I	2	0	0	2
MATH MATH	209/ 210	Complex Variables/Differential Equations	3	1	0	4
ENGG ENGG	201/ 202	Structure and Properties of Materials/Basic Electronics	4	0	0	4
CHE	202	Chemical Process Calculations	3	1	0	4
CHE	204	Heat Transfer	3	1	0	4
CS	209	Data Structures	4	0	0	4
CS	209L	Data Structures Lab	0	0	4	2
		Semester Total:	**21**	**3**	**4**	**26**

Semester – IV

Course	Code	Course Name	L	T	P	C*
		Core Foundation Course-IV	2	0	0	2
		Elective Foundation Course-II	2	0	0	2
MATH MATH	210/ 209	Differential Equations/Complex Variables	3	1	0	4
ENGG ENGG	202/ 201	Basic Electronics/Structure and Properties of Materials	4	0	0	4
CHE	201	Chemical Engineering Thermodynamics	3	1	0	4
CHE	203	Fluid Mechanics	3	1	0	4
CS	214	Object Oriented Programming	4	0	0	4
CS	214L	Object Oriented Programming Lab	0	0	4	2
CHE	315S	Seminar	0	0	4	2
		Semester Total:	**21**	**3**	**8**	**28**

Semester – V

Course Code	Course Name	L	T	P	C*
	Vocational Course-I	2	0	0	2
	Core Foundation Course-V/Elective Foundation Course-III	2	0	0	2
ECO 307/ MGMT 310	Fundamentals of Economics/Principles of Management	3	0	0	3
MATH 311/ STAT 204	Numerical Methods/Probability and Statistical Methods	3	1	0	4
CHE 309	Mass Transfer	3	1	0	4
CHE 312	Chemical Process Control	3	1	0	4
CHE 320	Mechanical Operations	3	1	0	4
CHE 307L	Environmental and Fuel Lab	0	0	4	2
CHE 318L	Fluid Mechanics and Mechanical Operations Lab	0	0	4	2
CHE 313L	Process Simulation Lab-I	0	0	4	2
	Semester Total:	**19**	**4**	**12**	**29**

Semester – VI

Course Code	Course Name	L	T	P	C*
	Vocational Course-II	2	0	0	2
	Elective Foundation Course-III/Core Foundation Course-V	2	0	0	2
MGMT 310/ ECO 307	Principles of Management/Fundamentals of Economics	3	0	0	3
STAT 204/ MATH 311	Probability and Statistical Methods/ Numerical Methods	3	1	0	4
CHE 303	Chemical Reaction Engineering	3	1	0	4
CHE 305	Chemical Technology	3	1	0	4
CHE 311	Plant Design and Economics	3	1	0	4
CHE 319L	Heat and Mass Transfer Lab	0	0	4	2
CHE 321L	Reaction Engineering and Process Control Lab	0	0	4	2
CHE 314L	Process Simulation Lab-II	0	0	4	2
	Semester Total:	**19**	**4**	**12**	**29**

Semester – VII

Course	Code	Course Name	L	T	P	C*
		Reading Elective	0	0	4	2
CHE	415P	UIL Project	0	0	48	24
		Semester Total:	**0**	**0**	**52**	**26**

Semester – VIII

Course	Code	Course Name	L	T	P	C*
CHE	308	Environmental Pollution Control	3	1	0	4
CHE	402	Chemical Plant Simulation	3	1	0	4
CHE	411	Process Plant Safety and Hazard Analysis	3	1	0	4
		Discipline Elective	3	1	0	4
		Open Elective	3	1	0	4
		Semester Total:	**15**	**5**	**0**	**20**

List of Discipline Electives

Course	Code	Course Name	L	T	P	C*
CHE	401	Biochemical Engineering	3	1	0	4
CHE	409	Petroleum Refining Technology	3	1	0	4
CHE	410	Polymer Science and Technology	3	1	0	4
CHE	414	Advanced Heat Transfer	3	1	0	4
CHE	304	Advanced Chemical Reaction Engineering	3	1	0	4
CHE	317	Advanced Mass Transfer	3	1	0	4
CHE	310	Optimizations of Chemical Processes	3	1	0	4
CHE	408	Nano-Science and Technology	3	1	0	4
CHE	406	Food Processing and Engineering	3	1	0	4
CHEM	301	Analytical Techniques	3	1	0	4
MCTR	403	Robotics and Automation	4	0	0	4
CS	507	Artificial Intelligence	4	0	0	4
CS	511	Cloud Computing	4	0	0	4

List of Reading Electives

Course	Code	Course Name	L	T	P	C*
CHE	419R	Membrane Separation Technology	0	0	4	2
CHE	417R	Corrosion Engineering	0	0	4	2
CHE	418R	Enzyme Engineering	0	0	4	2
CHE	420R	Renewable Energy Resources	0	0	4	2
CHE	416R	Computer Aided Process Plant Design	0	0	4	2

List of Core Foundation Courses

Course	Code	Course Name	L	T	P	C*
BVF	002	Environment Studies	2	0	0	2
BVF	013	Indian Cultural Heritage	2	0	0	2
BVF	017	Selected Writings of Great Authors-I	2	0	0	2
BVF	020	Women in Indian Society	2	0	0	2
BVF	015	Parenthood and Family Relation	2	0	0	2

List of Elective Foundation Courses

Course	Code	Course Name	L	T	P	C*
BVF	016	Science of Happiness	2	0	0	2
BVF	012	Human Body and Health	2	0	0	2
BVF	010	Design Thinking	2	0	0	2
BVF	019	Universal Human Values	2	0	0	2
BVF	018	Selected Writings of Great Authors-II	2	0	0	2

List of Vocational Courses

Course	Code	Course Name	L	T	P	C*
VOC	011L	Basic Dress Making	0	0	4	2
VOC	005L	Dress Designing	0	0	4	2
VOC	014	Entrepreneurship - I	2	0	0	2
VOC	015	Entrepreneurship - II	2	0	0	2
VOC	020	Radio Production - I	2	0	0	2
VOC	021	Radio Production - II	2	0	0	2
VOC	022	Web Designing and Internet Technology-I	1	0	0	1
VOC	022L	Web Designing and Internet Technology-I Lab	0	0	2	1
VOC	023	Web Designing and Internet Technology-II	1	0	0	1
VOC	023L	Web Designing and Internet Technology-II Lab	0	0	2	1
VOC	009	Library Science - I	1	0	0	1
VOC	009L	Library Science - I Lab	0	0	2	1

VOC	010	Library Science - II	1	0	0	1
VOC	010L	Library Science - II Lab	0	0	2	1
VOC	018	Photography – I	0	0	4	2
VOC	019	Photography - II	0	0	4	2
VOC	016	Introduction to Artificial Intelligence - I	2	0	0	2
VOC	017	Introduction to Artificial Intelligence - II	2	0	0	2
VOC	012	Computer Assisted Learning and Teaching	1	0	0	1
VOC	012L	Computer Assisted Learning and Teaching Lab	0	0	2	1
VOC	013	Emerging Technologies for Learning and Teaching	2	0	0	2

L - Lecture hrs/week; T - Tutorial hrs/week;
P-Project/Practical/Lab/All other non-classroom academic activities, etc. hrs/week; C - Credit Points of the Course

1. Student can opt for at most 2 additional Open (Generic) audit/credit Elective from other disciplines opting at most 1 per semester from Semesters III onwards with prior permission of respective heads and time table permitting.

2. Every Student shall also opt for:
   Five Fold Education: Physical Education I, Physical Education II,
   Five Fold Education: Aesthetic Education I, Aesthetic Education II,
   Five Fold Education: Practical Education I, Practical Education II
   one each semester

Note: Syllabus of Foundation and Vocational courses are available in separate booklet, "Curriculum Structure and Syllabus Foundation and Vocational Courses"

Project Evaluation Scheme

Duration	Course Code	Course Name	L	T	P	C
1 Semesters (5 months) 1 Jul - 30 Nov	CHE 415P	UIL Project	0	0	48	24

Continuous Assessment (40 Marks)

1. Joining report, brief project outlay	- 10 Marks
2. Synopsis	- 10 Marks
3. Mid-term evaluation by Supervisor	- 10 Marks
4. Further evaluation by Supervisor	- 10 Marks
Total	**- 40 Marks**

End Semester Assessment (60 Marks)

1. Project Report	- 20 marks
2. Presentation	- 20 Marks
3. Viva-voce	- 20 Marks
Total	**- 60 Marks**

Five Fold Activities

Aesthetic Education I/II		Physical Education I/II	
BVFF 101	Classical Dance (Bharatnatyam)	BVFF 201	Aerobics
BVFF 102	Classical Dance (Kathak)	BVFF 202	Archery
BVFF 103	Classical Dance (Manipuri)	BVFF 203	Athletics
BVFF 104	Creative Art	BVFF 204	Badminton
BVFF 105	Folk Dance	BVFF 205	Basketball
BVFF 106	Music-Instrumental (Guitar)	BVFF 206	Cricket
BVFF 107	Music-Instrumental (Orchestra)	BVFF 207	Equestrian
BVFF 108	Music-Instrumental (Sarod)	BVFF 208	Flying - Flight Radio Telephone Operator's Licence (Restricted)
BVFF 109	Music-Instrumental (Sitar)	BVFF 209	Flying - Student Pilot's Licence
BVFF 110	Music-Instrumental (Tabla)	BVFF 229	Aeromodelling
BVFF 111	Music-Instrumental (Violin)	BVFF 210	Football
BVFF 112	Music-Vocal	BVFF 211	Gymnastics
BVFF 113	Theatre	BVFF 212	Handball
Practical Education I/II		BVFF 213	Hockey
BVFF 301	Banasthali Sewa Dal	BVFF 214	Judo
BVFF 302	Extension Programs for Women Empowerment	BVFF 215	Kabaddi
BVFF 303	FM Radio	BVFF 216	Karate - Do
BVFF 304	Informal Education	BVFF 217	Kho-Kho
BVFF 305	National Service Scheme	BVFF 218	Net Ball
BVFF 306	National Cadet Corps	BVFF 219	Rope Mallakhamb
		BVFF 220	Shooting
		BVFF 221	Soft Ball
		BVFF 222	Swimming
		BVFF 223	Table Tennis
		BVFF 224	Tennis
		BVFF 225	Throwball
		BVFF 226	Volleyball
		BVFF 227	Weight Training
		BVFF 228	Yoga

Every Student shall also opt for:
Five Fold Education: Physical Education I, Physical Education II,
Five Fold Education: Aesthetic Education I, Aesthetic Education II,
Five Fold Education: Practical Education I, Practical Education II
one each semester

Evaluation Scheme and Grading System

Continuous Assessment (CA) (Max. Marks)					End-Semester Assessment (ESA) (Max. Marks)	Grand Total (Max. Marks)
Assignment		Periodical Test		Total (CA)		
I	II	I	II			
10	10	10	10	40	60	100

In all theory, laboratory and other non classroom activities (project, dissertation, seminar, etc.), the Continuous and End-semester assessment will be of 40 and 60 marks respectively. However, for Reading Elective, only End semester exam of 100 marks will be held. Wherever desired, the detailed breakup of continuous assessment marks (40), for project, practical, dissertation, seminar, etc shall be announced by respective departments in respective student handouts.

Based on the cumulative performance in the continuous and end-semester assessments, the grade obtained by the student in each course shall be awarded. The classification of grades is as under:

Letter Grade	Grade Point	Narration
O	10	Outstanding
A+	9	Excellent
A	8	Very Good
B+	7	Good
B	6	Above Average
C+	5	Average
C	4	Below Average
D	3	Marginal
E	2	Exposed
NC	0	Not Cleared

Based on the obtained grades, the Semester Grade Point Average shall be computed as under:

$$SGPA = \frac{CC_1 * GP_1 + CC_2 * GP_2 + CC_3 * GP_3 + ---- + CC_n * GP_n}{CC_1 + CC_2 + CC_3 + ---- + CC_n} = \frac{\sum_{i=1}^{n} CC_i * GP_i}{\sum_{i=1}^{n} CC_i}$$

Where n is the number of courses (with letter grading) registered in the semester, CC_i are the course credits attached to the i^{th} course with letter grading and GP_i is the letter grade point obtained in the i^{th} course. The courses which are given Non-Letter Grades are not considered in the calculation of SGPA.

The Cumulative Grade Point Average (CGPA) at the end of each semester shall be computed as under:

$$CGPA = \frac{CC_1 * GP_1 + CC_2 * GP_2 + CC_3 * GP_3 + ---- + CC_n * GP_n}{CC_1 + CC_2 + CC_3 + ---- + CC_n} = \frac{\sum_{i=1}^{n} CC_i * GP_i}{\sum_{i=1}^{n} CC_i}$$

Where n is the number of all the courses (with letter grading) that a student has taken up to the previous semester.

Student shall be required to maintain a minimum of 4.00 CGPA at the end of each semester. If a student's CGPA remains below 4.00 in two consecutive semesters, then the student will be placed under probation and the case will be referred to Academic Performance Review Committee (APRC) which will decide the course load of the student for successive semester till the student comes out of the probationary clause.

To clear a course of a degree program, a student should obtain letter grade C and above. However, D/E grade in two/one of the courses throughout the UG/PG degree program respectively shall be deemed to have cleared the respective course(s). The excess of two/one D/E course(s) in UG/PG degree program shall become the backlog course(s) and the student will be required to repeat and clear them in successive semester(s) by obtaining grade C or above.

After successfully clearing all the courses of the degree program, the student shall be awarded division as per following table.

Division	CGPA
Distinction	7.50 and above
First Division	6.00 to 7.49
Second Division	5.00 to 5.99
Pass	4.00 to 4.99

CGPA to % Conversion Formula: % of Marks Obtained = CGPA * 10

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Detailed Syllabus

FIRST AND SECOND SEMESTER

MATH 103 Calculus

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

After successful completion of the course, students will be able to:

- Define limit, infinite series and sequence of partial sums of an infinite series, Convergence and Divergence of an infinite series.
- Relate the limit of a function at a point to the limit of a sequence at that point and tell when a function will fail to have a limit at a point.
- Define monotonic functions and find a connection between monotonicity of a function and derivative of a function.
- Demonstrate the concept of Divergence, Curl, Green's theorem, Stokes's theorem.

Section A

Sequences, series, test for convergence, power series, radius of convergence; limit, continuity and differentiability (analytic definitions with simple examples); Rolle's Theorem, mean value theorem and Taylor's theorem; Successive differentiation: Leibnitz' theorem (without proof).

Section B

Review of vectors, Cylinders and quadric surfaces, Vector functions of one variable and their derivatives,Partial derivatives: Chain rule, exact differentials, Gradient, Directional derivative, Tangent planes and normals, Maxima and minima (two variables) including Lagrange's multipliers, Asymptotes and Curve tracing.

Section C

Riemann integral and the fundamental theorem of integral calculus, Reduction Formulae, Multiple integrals, Applications to multiple integrals to find length, area, surface area, volume, surface area of revolution, Improper integral.

Vector fields, Surface integral, Line integral, Independence of path, Conservative fields, Divergence, Curl, Green's theorem, Stokes's theorem.

Suggested Books:

1. Thomas, G.B., Weir, M.D., & Hass, J. (2011). *Thomas' Calculus* (11th ed.).Boston, MA: Pearson Education, Inc.
2. Kreyszig, E. (2011). *Advanced Engineering Mathematics* (9th ed.). Hoboken, NJ : John Wiley & Sons, Inc.
3. Apostol, T.M. (1980). *Calculus* (2nded.). New York, NY: John Wiley & Sons, Inc.
4. Grewal, B.S., & Grewal, J.S. (2012). Higher Engineering Mathematics (42thed.). India, Delhi: Khanna Publishers.

Suggested E-learning material:

1. Differentiation and Integration of Vector Functions

   http://vle.du.ac.in/pluginfile.php/837/mod_resource/content/0/Differentiation%20and%20Integration%20of%20Vector%20Functions.pdf
2. Mean Value Theorems

   http://vle.du.ac.in/pluginfile.php/844/mod_resource/content/0/Mean%20Value%20Theorems.pdf
3. Infinite Series

   http://vle.du.ac.in/pluginfile.php/861/mod_resource/content/0/Infinite%20Series.pdf

MATH 107 Linear Algebra

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

After successful completion of the course, students will be able to:

- Define basic terms and concepts of matrices, vectors and complex numbers
- Use basic vector space concepts such as linear space, linear dependence, basis, dimension, linear transformation;
- Be familiar with the concepts of eigenvalue, eigenspace and eigenvector and know how to compute these objects;
- Use the characteristic polynomial to compute the eigenvalues and eigenvectors of a square matrix and use them to diagonalise matrices

when this is possible; discriminate between 18iagonalizable and non-diagonalisable matrices.

- Use gauss-jordan elimination to solve systems of linear equations and to compute the inverse of an invertible matrix

Section A

Vectors, Algebra of vectors, vector spaces, subspaces, Linear sum and direct sum of subspaces, Linear combination, Linear span, Linear dependence and independence of vectors and its properties. Basis and dimension of vector space and subspace. Linear mappings, Kernel and Range of linear mapping, Singular and non-singular mappings.

Section B

Linear operator, Algebra of linear operators, Invertible operators, Matrix representation of a linear transformation, Change of basis, Range, rank and Kernel, nullity of a matrix, Elementary transformations, Matrix inversion with elementary transformations, Normal form of a matrix, System of linear equations.

Section C

Characteristics polynomial of a matrix, Characteristics values, Characteristics vector, Cayley-Hamilton theorem, Diagonalization of Matrices, Properties of characteristic values and characteristic vectors of Hermitian, skew-Hermitian, Unitary and Normal matrices (including Symmetric, Skew-symmetric and Orthogonal matrices).

Inner product spaces, Orthogonality, Orthogonal sets and bases, Gram-Schmidt orthogonalization process.

Suggested Books:

1. Axler, S. J. (1996*). Linear algebra done right*. New York: Springer.
2. Krishnamurthy, V., Mainra, V. P., & Arora, J. L. (1976). *An introduction to linear algebra*. New Delhi: East-West Press.
3. Friedberg, S. H., Insel, A. J., Spence, L. E., & Thiel, L. (2017). *Linear algebra*. Pearson Education.
4. Halmos, P. R. (2013). *Linear Algebra Problem Book*. Cambridge: Cambridge University Press.

5. Kumaresan, S. (2000). *Linear Algebra: A Geometric Approach*. New Delhi: Prentice-Hall (India).

Suggested E-learning material:

1. Lecture notes on linear Algebra
   https://nptel.ac.in/downloads/111102011/
2. Videos on Linear Algebra topics
   http://web.mit.edu/18.06/www/videos.shtml

PHY 101 Applied Optics

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

Upon successful completion, students will have the knowledge and skills to:

- Appreciate the efficacy of Fourier transforms and their application to physical systems.
- Understand linear, time-invariant systems.
- Understand the role of the wave equation and appreciate the universal nature of wave motion in a range of physical systems
- Understand dispersion in waves and model dispersion using Fourier theory.
- Understand diffraction and imaging in terms of Fourier optics and gain physical and intuitive insight in a range of physics.

Syllabus

Section A

Wave Optics- Interference: Superposition of Waves, Theory and method of measurement of wavelength of light and thickness of a thin transparent plate using Fresnel's Bi-prism, Interference in thin films, Newton's rings, Michelson's Interferometer,

Diffraction I: Fraunhofer's diffraction due to single slit, two parallel slits and N slits.

Section B

Diffraction II: Diffraction by plane transmission Grating (PTG), Characteristics of Grating Spectra, Measurement of Wavelength of light

using PTG, Concept of resolving power, Rayleigh's criterion of resolving limit, Resolving power of a Grating, Diffraction of X-rays and Bragg's law.

Polarization: Production and detection of plane, Circularly and elliptically polarized light, theory of the polarized light, Optical Activity, Fresnel's Explanation for optical rotation, Measurement of Specific rotation of a cane sugar solution using a Half Shade and a biquartz device polarimeter.

Section C

Modern Optics-Lasers : Spontaneous & Stimulates Emission, Einstein's Coefficient, Criterion of Laser action, Ruby and He-Ne Lasers, Characteristics of Laser light, Application of Laser with special emphasis on Holography.

Optical Fiber: Elementary idea of optical fiber, Light wave communication using optical fibers, Types of optical fibers, Step Index (Single mode and Multi mode) and Graded Index fiber, Light Propagation through optical fiber,

Ray Optics: Critical angle, Total internal reflection, Aceptance angle, Numerical aperture of an optical fiber.

Recommended Books:

1. Prakash S., Verma A. S., Gupta S. K. and Alvi P. A. (2015) A textbook of Optics and Modern Physics, Pragati Prakashan Meerut.
2. Allen S. R. (1997) An introducton to Fiber Optics, PHI
3. Seth S. P. (2007) Elements of Electromagnetic Field, Dhanpat Rai & Company.
4. Ghatak A. (2005) Optics, Tata McGraw hill publication
5. Beynon (1996) Introductory University optics, Prentice Hall of India Pvt. Ltd.
6. Thyagarajan and Ghatak (1981) Lasers Theory and Applications: Macmillan India Ltd
7. Senior John M. (2005) An introduction to Fiber Optics, PHI
8. Sadiku M. N. O (2007) Elements of Electromagnetics, Oxford University Press.

Suggested e-resources:

https://nptel.ac.in/course.php

PHY 106 Modern Physics

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

Upon successful completion, students will have the knowledge and skills to:

- Development of an understanding of the interrelationships of science, eengineering and technology.
    - Will have skill for problem solving and engineering skills, which then has broad applications.
    - Will have a career paths for Engineering physics are usually (broadly) "engineering, applied science or applied physics through research, teaching or entrepreneurial engineering". This interdisciplinary knowledge is designed for the continuous innovation occurring with technology.
    - Will have strong ground to provide a more thorough grounding in applied physics of any area chosen by the student (such as nanotechnology, mechanical engineering, electrical engineering, control theory, aerodynamics, or solid-state physics).

Section A

Special Theory of Relativity: Inertial and non-inertial frames of reference, postulates of special theory of relativity, Lorentz Transformations, Relativity of mass, length, time and velocity, Mass energy relation, energy momentum relation;

Wave Mechanics: Compton effect as evidence of quantum nature of radiation, Heisenberg's uncertainty principle, Time dependent & Time independent (Steady State) form of the Schrödinger equation, Solution of Schrodinger equation for free particle in a one dimension box and Potential step.

Section B

Free-electron model of metals, Origin of Bands in solids (Kronig-Penny model), E-k diagram, classification of solids as metal, semiconductors and insulators, Density of energy states and Fermi energy, Crystal structures of Si, Ge and GaAs, Electrical resistivity of semiconductors.

Superconductivity: Introduction, Types of superconductors, Properties of superconductors, Meisner effect, Joshephson effect, BCS theory of superconductivity (no derivation) only qualitative discussion, High Temperature superconductors, Applications of superconductors.

Section C

Dielectric Materials: Dielectric Constant, Type of Dielectrics, Polarization of Dielectrics, Polarization density, Relation between dielectric constant and electric susceptibility, Types of Polarization (Electronic polarization, ionic polarization, orientation polarization), Clausius-Mosotti Equation, **Nuclear Physics**: Nuclear Binding Energy, Fission and Fusion Reactions, Construction, theory and applications of Geiger Muller Counter , Proportional and Scintillation Counter.

Recommended Books:

1. Beiser, A. (2003). Concepts of modern physics. Tata McGraw-Hill Education.
2. Krane, K. S. (1995). Modern physics. Modern Physics, 2nd Edition, by Kenneth S. Krane,. ISBN 0-471-82872-6. Wiley-VCH, August 1995.,
3. Birkhoff, G. D., & Langer, R. E. (1923). Relativity and modern physics. Harvard University Press.
4. Leighton, R. B., & Leighton, R. B. (1959). Principles of modern physics (Vol. 795). New York: McGraw-Hill.
5. Prakash S., Verma A. S., Gupta S. K. and Alvi P. A. (2015) A textbook of Optics and Modern Physics, Pragati Prakashan Meerut
6. Raghuvanshi (2008) Engineering Physics, Tata Mc Hill

Suggested e-resources:

https://nptel.ac.in/course.php

CHEM 101 Chemistry

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcome:

On completion of course, the students will be able to:

- explain the basics of atomic structure and chemical bonding.
- explain the behavior of the system through phase, degree of freedom and component.
- explain the basics of electrochemistry, different type of corrosion and their prevention.
- differentiate nanoscience, nanotechnology, nanochemistry, conventional and non-conventional energy sources and their applications.

Section A

Atomic Structure: Introduction, Schrodinger wave equation, significance of Ψ and Ψ^2, quantum numbers, radial and angular wave function, probability distribution curves, shapes of *s, p, d* orbitals. Aufbau and Pauli principles, Hund's multiplicity rule, fiiling of electron upto 71 elements, exchange energy, pairing energy, symmetrical distribution of charge, extra stability of half-filled and completely-filled orbitals, Slater's rules for evaluation of shielding constant and effective nuclear charge.

Covalent bond: Introduction, Valence bond theory and its limitations, directional characteristics of covalent bond, various types of hybridization and shapes of simple inorganic molecules and ions, valence shell electron pair repulsion (VSEPR) theory with reference to $BeCl_2$, $SnCl_2$, BF_3, BF_4^-, NH_3, H_2O, H_3O^+, PCl_5, SF_4, CIF_3, I_3^-, SF_6, IF_7, ICI_2^-, and $POCl_3$; MO theory, sigma and pi Molecular orbitals theory, homonuclear and heteronuclear (CO, NO) diatomic molecules and their ions.

Section B

Electrochemistry: Electric transport in electrolytic solutions, specific conductance and equivalent conductance, measurement of equivalent conductance, variation of equivalent and specific conductance with dilution, migration of ions and Kohlrausch law, Arrhenius theory of electrolyte dissociation and its uses and limitations, Debye-Huckel-Onsager's equation for strong electrolytes (elementary treatment only), applications of

conductivity measurement: determination of degree of dissociation, determination of K_a of acids, determination of solubility product of sparingly soluble salt, conductometric titrations.

Phase Rule: Phase, component, degree of freedom or variance; phase diagram of one-component system: -water system, sulphur system, CO_2 system, phase rule for two-component system: reduced phase rule, eutectic point., Pb-Ag system and its applications.

Corrosion: Definition, types (Dry, Wet, Pitting, Stressed, Galvanic Cell, Water Line and Concentration Cell Corrosion), its significance, Mechanisms of corrosion, Protection from corrosion: Protective coatings, Cathodic protection, sacrificial anode and Modification in designs etc.

Section C

Water: Hardness, types of Hardness, Degree of hardness, determination of hardness by Clark's test and Complex metric (EDTA) method, degree of hardness, numerical based on EDTA and Clark's method, Boiler troubles their causes, disadvantages and prevention, Formation of solids (Scale and Sludge), Carry over (Priming and Foaming), Corrosion and Caustic Embrittlement, Advanced methods of water starelization, Softening of water by Lime-Soda Method, Permutit (Zeolite) Method and Deionization or Demineralization Method, Numerical problems based on Lime-Soda and Zeolite softening methods

Organic Electronic Materials: Introduction**,** classification, factor affecting the conductivity of polymers, Applications.

Optical fires: Introduction, properties, preparation, optical fiber grade glass and uses.

Non-conventional energy: Introduction of solar energy, Application of solar energy, Photovoltaic cell, conversion of solar energy, Biofuel and biomass, Superiority of non-conventional source of energy over conventional energy.

Recommended Books:

1. B.R. Puri and L.R. Sharma & K.C. Kalia (2017), *Principles of Inorganic Chemistry*, 33rd Ed.,Vishal Publications.
2. L.R Sharma, M.S Pathania B.R Puri and Navjot Kaur (2018), A Textbook of Physical Chemistry, Vishal Publications.
3. W. U. Malik, G.D.Tuli & R. D. Madan (2010), *Selected Topics in Inorganic Chemistry*, Revised Ed., S. Chand Publications.
4. Gurdeep Raj(2014), Advanced Physical Chemistry, goel publications.
5. J.D. Lee (1998), *Concise Inorganic Chemistry*,5th Ed, Oxford Publications.
6. F. A. Cotton and G. Wilkinson (1994), *Basic Inorganic Chemistry*,3rd Ed., John Wiley **Publications**.
7. P. Bhagchandani (2017), *Inorganic* Chemistry, Sahitya Bhawan Publications.
8. S.S. Dara and S.S.Umare (2004), Textbook of Engineering Chemistry, S. Chand **Publications**.

Suggested e-Sources:

1. National Programme on Technology Enhanced Learning
   https://nptel.ac.in
2. Online Chemistry Courses
   https://www.edx.org/learn/chemistry
3. Free Online Education SWAYAM
   https://swayam.gov.in

BIO 101 Biology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

After successful completion of the course, students should be able to:

- Understand the basic organization and classification of living organisms.
- Gain broad understanding of cellular functions.
- Understand the fundamental concepts of molecular biology and recombinant DNA technology.

Section A

- Brief idea of origin of life, Viruses (TMV, HIV, Bacteriophages), overview and brief introduction to five kingdom classification, characteristic features of Protista, Plantae and Animalia.
- Morphology and functions of different parts of flowering plants: Root, stem, leaf, major inflorescence (Spike, Raceme, Corymb and Umbel), flower, fruit and seed.
- Brief about the components and functions of different systems of humans.

Section B

- The cell concept, prokaryotic (Bacteria, cell structure) and eukaryotic cell (plant and animal cell). Cell organelles and their functions.
- Brief introduction and significance of carbohydrates, lipids, proteins and enzymes.
- Mendelian inheritance chromosome theory of inheritance, deviations from mendelian ratio (Incomplete dominance, co-dominance, complementary genes, multiple alleles). Linkage and crossing over, sex determination, sex linked inheritance, genetic counseling.

Section C

- Structure and replication of DNA, structure of RNA and brief concept of transcription and translation in prokaryotes and comparison with eukaryotes, Genetic code, Basic concept of recombinant DNA Technology and its applications. Overview of Human Genome Project, Biosafety issues.

Suggested Books:

- Green, N. P. O., Stout, G. W., Taylor, D. J. & Soper, R. (2005). *Biological Sciences*. Cambridge University Press.
- Reece, J. B., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., & Jackson, R.B. (2013). *Campbell Biology*. Pearson Publisher, India.

Suggested e-Resources:

- **Structural organization of plants and animals** https://www.emedicalprep.com/study-material/biology/structural-organization-in-plants-and-animals/
- **Morphology, anatomy and functions of different systems of humans:**

  https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-body-structure-and-homeostasis/a/tissues-organs-organ-systems
- **Basic concept of cell**

  https://biologydictionary.net/cell/
- **Gene-gene interaction**
  http://www.biologydiscussion.com/genetics/gene-interactions/gene-interactions-allelic-and-non-allelic-cell-biology/38795
- **Human genome project**

  https://www.genome.gov/12011238/an-overview-of-the-human-genome-project/
- **Application of recombinant DNA technology:**

  https://medcraveonline.com/JABB/JABB-01-00013

CHE 102 Thermodynamics

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning outcomes:

The students will be able to:

- Carryout thermodynamic analysis of real systems.
- Carryout thermodynamic analysis multiphase systems with chemical changes.
- Understand thermodynamic functions and their relationships

Section A

Definition, significance and limitations, Classical versus statistical thermodynamics, definition of thermodynamic terms: system, surroundings etc., types of systems, intensive and extensive properties, state and path functions and their differentials, Euler reciprocity relation and cyclic rule, thermodynamic process, concept of heat and work.

First law of thermodynamics: statement, definition of internal energy and enthalpy, heat capacity-heat capacities at constant volume and pressure and their relationship, Bomb calorimeter, Joule's Law, Joule-Thomson coefficient and inversion temperature, calculation of w, q, ΔU & ΔH for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process, application of first law of thermodynamics in closed systems, zeroth law of thermodynamics and the absolute temperature scale.

Section B

Thermochemistry: Heat of reaction at constant pressure and at constant volume, Hess's law of heat summation and its application, temperature dependence of enthalpy (Kirchhoff's equation), bond dissociation energy and its calculation from thermo-chemical data,

Second law of Thermodynamics: need for the law, different statements of the law, Carnot cycle and its efficiency, Carnot theorem, Heat Engine, Efficiencies, thermodynamic scale of temperature.

Concept of Entropy: Entropy as a state function, entropy as a function of V & T, entropy as a function of P & T, entropy change in physical change, Clausius inequality, entropy as a criteria of spontaneity and equilibrium, entropy change in ideal gases and mixing of gases.

Section C

Thermodynamic Relations: Maxwell's equations, TdS equations, difference in heat capacities, ratio of heat capacities, energy equations, Joule-Kelvin effect, Clausius-Clapeyron equation.

Third law of Thermodynamics: Nernst heat theorem, statement and concept of residual entropy, evaluation of absolute entropy from heat capacity data, Gibb's and Helmholtz functions: Gibbs-Helmholtz equation, Gibbs function (G) and Helmholtz function (A) as thermodynamic quantities, A & G as criteria for thermodynamic equilibrium and spontaneity, their advantage over entropy change, variation of G and A with P, V and T.

Recommended Books:

1. Atkins, P. W., & De, P. J. (2006). Atkins' physical chemistry. Oxford: Oxford University Press.
2. Puri, S., Sharma, R. L., & Pathania M. S. (2004). Principles of physical chemistry. Vishal Publishing Co.
3. Sharma, K. K., & Sharma, L. K. (1977). A textbook of physical chemistry. Vikas Publishing House.
4. P. K. Nag (2009). Basic & applied thermodynamics. Tata McGraw Hill.
5. Van Ness, H. C. (1983). Understanding thermodynamics. Courier Corporation.
6. Van Wylen, G. J., & Sonntag, R. E. (1985). Fundamentals of classical thermodynamics. New York: Wiley.

E-resource(s):

1. https://nptel.ac.in

PHY 109 Engineering Mechanics

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

Upon successful completion, students will have the knowledge and skills to:

- Students will demonstrate proficiency in mathematics and the mathematical concepts needed for a proper understanding of physics.
- Students will show that they have learned concept of Newtonian mechanics and kinematics.
- Students will be capable of oral and written scientific communication, and will prove that they can think critically and work independently

Section A

System of forces, Fundamental laws of mechanics, Composition of forces, Free body diagram, Lami's theorem, Moments and couple, Varignon's theorem, Condition of equilibrium, Types of support and loading, Reaction, Analysis of simple trusses by methods of joints and methods of sections. The laws of Coulomb friction, Ladder, wedges, Belt friction and rolling, Principle of virtual work and its applications.

Section B

Location of centroid and center of gravity, area moment of inertia, mass moment of inertia law of mechanics, Variation of mechanical advantages, efficiency, reversibility of machine Pulleys, wheel and axle, wheel and differential axle, Transmission of power through a belt and rope, Moment of inertia of masses- Transfer formula for mass moments of inertia- Mass moment of inertia of composite bodies.

Section C

Kinematics of a Particle: Rectilinear motion, plane curvilinear motion, Projectile motion, Constrained motion of connected particles.

Dynamics of Particles and Rigid Body: Newton's Law of motion, D'Alembert's principle.

Work & energy: Work, Energy (Potential, kinetic and spring), Work-Energy relation, Law of conservation of energy,

Impulse & momentum: Impulse, momentum, Impulse-momentum relation, Impact

Vibration: Definitions, Concepts- simple harmonic motion-free vibrations-simple and compound pendulums-torsional vibrations.

Recommended Books:

1. Kumar D. S. (2009) Engineering Mechanics, Laxmi Publication
2. Dubey N. H (2015) Engineering Mechanics, McGraw Hill Edu
3. Sharma M. (2009) Engineering Mechanics, CBH
4. Sharma (2009) Mechanics, Pearson

Suggested e-resources:

1. https://nptel.ac.in/course.php

CS 109 Computer Fundamentals and Programming

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After successful completion of the course, students will be able to:

- Describe the concepts of computer basics and programming.
- Explain the organization and operations of a computer system.
- Design the combinational and sequential circuits.
- Employ the logical thinking for analyzing problems, designing and implementing algorithmic solutions.
- Employ the skills for the use of the C programming language to implement the real world applications.

Section A

Brief introduction to computer organization, Block diagram, Hardware and software. Introduction to operating System, Concept of Data and Information, Representation of data, bits and bytes, Number System

(binary, octal, decimal, hexadecimal), Representation of integers, real numbers, positive and negative numbers, Binary arithmetic, simple concepts and theorems of Boolean algebra. Representation of characters: BCD, ASCII, EBCDIC codes. Programming fundamentals: Program, Steps in program development, programming language, compilers, interpreters. Algorithms, flowcharts, Control statements sequencing, conditional and unconditional branching and looping.

Section B

Overview of C language- History, structure of a program data types, variables, constants, operators (arithmetic, logical, relational), expressions (arithmetic and logical), assignments, conditional statements, control statements, simple I/O. Single and multi-dimensional arrays, Searching (linear, binary), sorting (bubble, selection) and merging, matrix arithmetic.

Section C

Concept of pointers, pointer expression, pointer v/s arrays, functions, parameter passing (call by value, call by reference), recursion, structure, union and enumerated data types, concept of structured programming.

Suggested Books:

1. Sinha, P. K. (2003). *Computer fundamentals: concepts, systems & applications*. BPB publications.
2. Balagurusamy, E. (2012). *Programming in ANSI C*. Tata McGraw-Hill Education.
3. Kanetkar, Y. P. (2016). *Let us C*. BPB publications.
4. Rajaraman, V., & ADABALA, N. (2014). *Fundamentals of computers*. PHI Learning Pvt. Ltd.

Suggested E-learning material:

1. Introduction to Programming in C
   https://nptel.ac.in/courses/106104128/
2. Introduction to Programming in C Specialization
   https://www.coursera.org/specializations/c-programming
3. Sinha, P. K. (2003). Computer fundamentals: concepts, systems & applications. BPB publications.

https://www.edutechlearners.com/computer-fundamentals-p-k-sinha-free-pdf/

CS 109L Computer Fundamentals and Programming Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course, students will be able to:

- Perform internal and external DOS commands.
- Implement problems based on expressions containing constants, variables and operators.
- Implement problems based on conditional statements, switch and loops.
- Implement problems based on array, pointers, functions, files and command line arguments.

Lab Exercise

1. Explore DOS & WINDOWS Operating System
2. Implement Following programs in 'C'
   - I. Simple Programs
     - i. Arithmetic Calculation
     - ii. Formula Based Calculation
   - II. Conditional Statements
     - i. Check odd-even, positive-negative
     - ii. Calculation of Division, Rank of student
     - iii. Solution of Quadratic Equations
     - iv. Menu Driven Programs
     - v. Programs using if and switch statement
   - III. Looping
     - i. Sum of digits of number, reverse of number, palindrome checking
     - ii. Table Generation
     - iii. Prime number checking, generation

iv. Calculation of GCD, LCM
v. Sum of various series, Fibonacci series,sin, cos, exp etc.
vi. Pattern Drawing

IV. Programming with Arrays
i. Max, min & Average calculation
ii. Linear Search
iii. Binary Search
iv. Bubble Sort
v. Selection Sort
vi. Merging
vii. Number System Conversion
viii. Matrix Manipulation- sum of row, column & diagonal element
ix. Display and sum of upper triangular, lower triangular matrix elements
x. Matrix Arithmetic (Addition, Subtraction, Multiplication)
xi. String Manipulation

V. Pointers and Functions
i. Use of Functions the previous programs
ii. Use of pointers and function in array and string processing
iii. Recursion-factorial, GCD, Fibonacci, Power, Tower of Hanoi etc.

VI. Structures
i. Operations on Complex number
ii. Record storage, searching, sorting, generating reports
iii. Use of Union

EEE 101 Electrical Engineering

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes

The Students will be able to:

- Understand the importance of electrical engineering
- Solve complex DC circuits
- Solve& predict the behavior of AC circuit
- Understand different machines along with measurement techniques
- Select appropriate element, device or machines with respect to application

SECTION A

DC Networks: Node Voltage and Mesh Current Analysis; Source Conversion. Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum power Transform, Laplace transforms and inverse Laplace transforms: Basic Theorem and Circuit analysis using Laplace transformations, Initial and final value theorem.

SECTION B

Single Phase AC Circuits: EMF Equation, Average, RMS and Effective Values. RLC Series, Parallel and Series, Parallel Circuits, Complex Representation of Impedances. Phasor Diagram, Power and Power Factor.

Three Phase A.C. Circuits: Delta-Star and Star-Delta Transformation, Line & Phase Quantities, 3-Phase Balanced Circuits, Phasor diagram, Measurement of Power in Three Phase Balanced Circuits.

SECTION C

Transformer: Magnetic coupled circuits, Dot convention for coupled circuits, coefficient of coupling, mutual inductance, EMF Equation, Voltage & Current, Relationship and Phasor Diagram of Ideal Transformer.

Introduction to principle of DC Machines, synchronous machines and induction motors.

Text Books

1. Toro, V. D. (1989). *Electrical Engineering Fundamentals* (2nd ed.). PHI Publication.

2. Bobrow, L. S. (1996). *Fundamental of Electrical Engineering*(2nd ed.). Oxford Publication.
3. Nagrath,J. &Kothari,D.P. (2017).*Basic Electrical Engineering*(3rd ed.).India: TMH.
4. Sahdev,S. K. (2015). *Basic Electrical Engineering*. India: PearsonEducation India.

Reference Books

1. Chakrabarti,A.K. (2018). *Circuit Theory* (7th ed.). Dhanpat Rai and Co.
2. Alaxender, C. &Sadiku, M. N. O. (2003). *Fundamentals of Electrical circuits.* Oxford University Press.
3. Choudhary, D. R. (2013). *Networks and Systems.* Wiley Eastern Ltd.
4. Hayt, W. H., Kemmerly, J.&Durbin,S. M. (2013). *Engineering Circuit analysis*(8th ed.).Tata Mc Graw Hill.
5. Valkenburg, M.E.V.(2006). *Network Analysis*. New Delhi: Prentice Hall.

E-Resources:

1. https://nptel.ac.in/courses/108108076/
2. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/
3. https://swayam.gov.in/electrical/c/4/engineering
4. https://swayam.gov.in/courses/4746-july-2018-fundamentals-of-electrical-engineering
5. https://nptel.ac.in/courses/108105053/pdf/L-03(GDR)(ET)%20((EE)NPTEL).pdf
6. https://nptel.ac.in/courses/108105053/pdf/L-04(GDR)(ET)%20((EE)NPTEL).pdf
7. https://nptel.ac.in/courses/108105053/pdf/L-06(GDR)(ET)%20((EE)NPTEL).pdf
8. https://nptel.ac.in/courses/108105053/pdf/L-07(GDR)(ET)%20((EE)NPTEL).pdf
9. https://nptel.ac.in/courses/108105053/pdf/L-08(GDR)(ET)%20((EE)NPTEL).pdf

10. https://nptel.ac.in/courses/108105053/pdf/L-14(NKD)(ET)%20((EE)NPTEL).pdf
11. https://nptel.ac.in/courses/108105053/pdf/L-15(NKD)(ET)%20((EE)NPTEL).pdf
12. https://nptel.ac.in/courses/108105053/pdf/L-17(NKD)(ET)%20((EE)NPTEL).pdf
13. https://nptel.ac.in/courses/108105053/pdf/L23(TB)(ET)%20((EE)NPTEL).pdf
14. https://www.scribd.com/doc/123459017/basic-electrical engineering?campaign=SkimbitLtd&ad_group=725X1342X724adc86fb3fde3cdc1f294ab4f382ea&keyword=660149026&source=hp_affiliate&medium=affiliate

EEE 101L Electrical Engineering Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes

The Students will be able to:

- Handle measuring instruments and apparatus
- Identify the various electrical and electronic components as per the ratings
- Verify circuit laws and solve electrical networks
- Analyze the characteristics of semiconductor devices
- Design basic AC & DC circuits

LIST OF EXPERIMENTS

1. Study of electronic components and apparatus.
2. Study ofdigital& analog Multimeter.
3. Study of Cathode Ray Oscilloscope (CRO)

4. Verification of principle of Superposition Theorem with DC.
5. Verification of principle of Thevenin's theorem with DC.
6. Verification of principle of Norton's theorem with DC.
7. Verification of principle of Maximum Power Transfer with DC.
8. Determine the frequency response of current in RL & RC circuit.
9. Determine the frequency response of current in RLC circuit.
10. Study of VI characteristics of PN junction diode.
11. Study ofVI characteristics of Zener diode.
12. Study ofVI characteristics of LED, LDR and Photodiode.
13. Study of VI characteristics of BJT in CE configuration.

ENGG 101L Engineering Drawing and Graphics Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**6**	**3**

Learning Outcomes

The Students will be able to:

- Apply the concepts of engineering drawing in their respective field of interest.
- Implement various BIS and ISO concepts of drawing.
- Draw the sectional views of various engineering objects.
- Use engineering curves in tracing the paths of simple machine components.
- Draw various views related to real objects.
- Draw and read plan of industrial standards.
- Visualize the design ideas using software.

Indian Standard –Drawing Instruments, Lines & Lines symbols; Sheet Layout of rules of printing; Line sections & Conventions, Lettering, Scales, Curved used in Engineering Practice, Projection of Points, Projection of Lines, Projection of Planes, Projection of Solids, Orthographic Projections,

Sectional Views, Rivets & Riveting Joints, Threads, Foundation Bolts & Nuts.

Computer Aided Drawing using Auto CAD /MICRO STATION.

Text Books:

1. Gill,P. S. (2010).*Engineering Drawing*. Kataria Publication,.
2. Bhatt,N. D. & Panchal, V.M. (2011). *Geometrical and Machine Drawing* (19th ed.). Charotar Publication.

e-Resources:-

1. https://nptel.ac.in/courses/112103019/
2. http://www.me.umn.edu/courses/me2011/handouts/drawing/blanco-tutorial.html
3. https://ocw.mit.edu/courses/mechanical-engineering/2-007-design-and-manufacturing-i-spring-2009/related-resources/drawing_and_ sketching/
4. https://nptel.ac.in/courses/112104172/

LIST OF EXPERIMENTS

1. Drawing sheet related to lettering.
2. Drawing sheet related to scale.
3. Drawing sheets related to conic sections.
4. Drawing sheets related to Engineering Curves.
5. Drawing sheet related to Projection of points.
6. Drawing sheet related to Projection of lines.
7. Drawing sheet related to orthographic projection by 1st angle.
8. Drawing sheet related to orthographic projection by 3rd angle.

ENGG 103L Measurement Techniques Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**6**	**3**

Learning Outcomes:

After successful completion of the course, students should be able to:

- Perform adulteration test and qualitative analysis of biomolecules.
- Familiarize with the working principle of microscope.
- Understand the fundamental concepts of plant identification and vegetational analysis.
- Gain hand on training to check purity of biomolecules.

Biology

1. To test for adulteration in turmeric, wheat flour, ghee and milk.
2. Qualitative analysis of nitrate, carbonate and replaceable base deficiency in soil samples.
3. Determination of soil pH.
4. Biochemical test for sugar, albumin and ketone bodies in urine samples.
5. Biochemical tests for lipids and cholesterol.
6. Detection of Vitamin A in the given sample.
7. Study of typical prokaryotic and eukaryotic cells with the help of a microscope.
8. Gram staining to identify gram positive and gram negative bacteria
9. Description of plant identification (Neem, Babool, Peeli Kaner, Tulsi & Chandani, Aak/ Madar).
10. Vegetational analysis by Quadrat method.
11. Determination of concentration and purity of DNA.
12. Determination of concentration and purity of RNA.
13. Preparation of stained temporary mount of onion peel.

Suggested Books:

- Biradar, V.K., & Samshe, A. (2016). *Practical Biochemistry*. New Delhi: APH Publishing Corporation.

- Sharma, S., & Sharma, R. (2016). *Practical Manual of Biochemistry* (2nd ed.). New Delhi: Medtech.
- Vats, S. (2015). *A laboratory Text book of Biochemistry, Molecular Biology and Microbiology*. Germany: GRIN Verlag.
- Yadav, V.K., & Yadav, N. (2018). *Biochemistry & Biotechnology: A Laboratory Manual*. Jaipur: Pointer Publisher.

THIRD AND FOURTH SEMESTER

MATH 209 Complex Variables

Max. Marks : 100	L	T	P	C
(CA: 40 + ESA: 60)	3	1	0	4

Learning Outcomes:

On completion of the course, students will be able to:

- Demonstrate an understanding of the basic concepts of underlying complex analysis.
- Explain the essential concepts of complex functions and their role in applied contexts.
- Investigate limit, continuity and differentiability of complex functions.
- Demonstrate capacity for mathematical reasoning through analyzing analytic functions.
- Use complex analysis techniques to solve problems in diverse situation in physics, engineering and other mathematical contexts.
- Demonstrate an understanding to determine the singularity of the complex functions
- Demonstrate an understanding of Fourier series, Fourier integrals and Fourier transforms.

Section A

Complex functions; Exponential function, Trigomometric and hyperbolic function, Polar form, branch cuts.Continuity, Differentiability, Analytic function, Cauchy-Riemann equations, Harmonic functions.

Section B

Conformal map, Bilinear Transformation, Line integral in complex plane, Cauchy's Integral theorem, Cauchy's integral formula, Derivative of analytic functions, Power series, Taylor's series, Laurent series,

Section C

Singularities, Residue, Residue theorem and Evaluation of real integrals.

Fourier series, half-range expansions, Fourier integrals, Fourier transforms: Fourier sine and cosine transform, Inverse Fourier transforms.

Suggested Books:

1. Kasana, H. S. (2005).*Complex Variables: Theory and Applications* (2nd ed.). India, Delhi:PHI Learning Pvt. Ltd.

2. Ramana, B.V. (2015), *Higher Engineering Mathematics* (25th ed.).India, Delhi: Tata McGraw Hill Co. Ltd.
3. Kreyszig, E. (2011). *Advanced Engineering Mathematics* (9th ed.). Hoboken, NJ : John Wiley & Sons, Inc.

Suggested E-Learning Material:

1. Complex Analysis
   https://nptel.ac.in/courses/111103070/

MATH 210 Differential Equations

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

On completion of the course, students will be able to:

- Solve nth order homogeneous differential equations with constant coefficient and Euler Cauchy differential equations.
- Understand some methods such as Variation of parameters, Methods of undetermined coefficient and Frobenius method for solving a differential equation.
- Solve Laplace transformation, Inverse Laplace transformation.
- Solve Ordinary differential equation by using Laplace transformation.
- Solve homogeneous and non-homogeneous linear Partial differential equations with constant coefficients.
- Understand the use of Partial differential equations in solving Heat, Wave and Laplace equations.

Section A

Ordinary differential equation of the 1st order and 1st degree; Ordinary linear differential equation of nth order- homogeneous and non-homogeneous with constant coefficient; Euler Cauchy differential equations, Variation of parameters, Methods of undetermined coefficients, System of linear differential equations.

Section B

Power series solutions of ordinary differential equations,Frobenius Method, Legendre equation and Legendre polynomials, Bessel equations and Bessel functions of first and second kind.

Laplace transform and its properties; Convolutions, Inverse Laplace transform, application of Laplace transform for solving ordinary differential equations.

Section C

Partial differential equations of first order, homogeneous and non-homogeneous linear partial differential equations with constant coefficients, Classification of second order Partial differential equations; Solution of one dimensional wave and heat equation, solution of Laplace equation

Suggested Books:

1. Ramana, B.V. (2017). *Higher engineering mathematics*. Mc Graw Hill.
2. Kreyszig, E. (2005). *Advance engineering mathematics.* Wiley Eastern.
3. Zill, D.G. (2013). A first course in differential equation with modeling application. Cengage Learning.

Suggested E-Learning Material:

1. Differential Equations for Engineers
   https://nptel.ac.in/courses/111106100/
2. Differential Equations
   https://ocw.mit.edu/courses/mathematics/18-03-differential-equations-spring-2010/
3. Differential Equations
   https://freevideolectures.com/course/3302/differential-equations-i
4. Differential Equations
   https://www.khanacademy.org/math/differential-equations

ENGG 201 Structure and Properties of Materials

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

The students will be able to:

- Relate fundamentals of material properties with its utilization
- Design and develop better products and equipment
- Identify needs and applications of materials economically.

Section A

Atomic bonding in solids: Bonding forces and energies; primary and secondary bonding; Metallic structures: unit cells, crystal systems, crystallographic directions and Miller-Bravais indices, linear and planar densities, close-packed crystal structures; Polymer structure: molecular weight, molecular configurations of polymer; Defects and dislocations: vacancies and interstitials dislocations, grain boundaries; Mechanical test behaviour of metals: elastic and plastic deformation.

Section B

Deformation mechanisms: slip system, plastic deformation, strengthening mechanisms; Diffusion; Phase diagram: phases, micro structure, phase equilibrium, Iron-carbon system: Fe-Fe3C phase diagram, development of microstructure in Fe-C alloys, mechanical behaviour of Fe-C alloy, Tempered Martensite; Kinetics of phase transformations: Avrami rate equation, correlation of properties to microstructure, isothermal transformation diagram, continuous cooling transformation.

Section C

Magnetic materials: dia, para, ferroand ferrimagnetism; soft and hard magnetic materials and their applications; Conductive materials: electrical properties of conductive and resistive materials, important characteristics and electronic applications of specific conductive & resistive materials; Semiconductor materials: crystal growth, zone refining, degenerated and non-degenerated semiconductors, direct and indirect band-gap semiconductors.

Recommended Books:

1. Callister, W. D., & Rethwisch, D. G. (2018). Materials science and engineering: An introduction.
2. Shackelford, J. F. (2014). Introduction to materials science for engineers. Pearson.
3. Viswanathan B. (2006). Structure and properties of solid state materials. Alpha Science Intl. Ltd .
4. Budinski, K. G., & Budinski, M. K. (2016). Engineering materials: Properties and selection. New Delhi: Pearson India Education.

E-resource(s): https://nptel.ac.in

ENGG 202 Basic Electronics

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes: After successful completion of the course, student will be able to:

- Understand the fundamental of semiconductors and design semiconductor circuits.
- Understand the different type of diode/ transistors with their responses.
- Analyze various types of oscillators available with their utilization.

Section A

Electronics component- Active & Passive components, Types of resistors, inductors & capacitors, Recapitulation of semiconductor, Intrinsic and Extrinsic Semiconductor, Charge density of semiconductors generation and recombination of charges, diffusion, the continuity equation, Injected minority carrier charges, potential variation with in a graded semiconductor, Potential variation in step graded junction, PN Junction diode, current components, volt Ampere characteristic-temperature dependency, space charge & diffusion capacitance, switching time

Section B

Breakdown diode, Tunnel diode, LED, Photo diode, load line, clipping, clamping. The junction Transistor, current, components, configuration - CB, CE, CC, Typical junction values, Ebers-Moll model, photo transistor, analysis of transistor amplifier using h parameter Transistor Hybrid Model, , Emitter follower, Darlington pair, Miller theorem & its Dual, cascading amplifier

Section C

Biasing and stabilization - Static & Dynamic, Bias stability, load line, Need of stabilization, self-bias, fixed bias, emitter bias, feedback bias, Transistor as an Inverter, brief introduction of different coupling techniques

FET- Pinch off, V-I characteristics, MOSFET- Depletion & Enhancement type, Oscillators- Barkhausen criterion, phase shift oscillator, General form of oscillator circuit - Colpitts, Hartley, Wein bridge, crystal oscillator

Recommended Books:

1. Millman. J, Halkias. C, Parikh. C. (2017). *Integrated Electronics*. *(2/e).* New Delhi: TMH Publications.

2. Boylestad.R. (2012). *Electronic Devices& Circuits Theory.(6/e).* New Delhi: Pearson Publications.
3. Somanathan B. Nair. (2006). *Electronics Devices and Applications.* New Delhi: Prentice Hall India Learning Private Limited
4. Smith. S.(2008). *Microelectronics Circuits. (5/e).* New Delhi: Oxford press, India.
5. Streetman Ben. G. (2006). *Solid State Electronic Devices (6/e)*. New Delhi: PHI Publications.

Suggested E-resources:

1. **Basic Electronics** by Prof. Pramod Agarwal, Department of Electrical Engineering, Indian Institute of Technology, Roorkee. https://nptel.ac.in/courses/117107095/4
2. Circuits and Electronics by Anant Agarwal, Massachusetts Institute of Technology: MIT OpenCourseWare.

   https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/video-lectures/6002_l16.pdf

CHE 202 Chemical Process Calculations

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

The students will be able to:

- Make material balances on unit operations and processes
- Perform simultaneous material and energy balances
- Understanding the degrees of freedom analysis and its significance
- Understand the concept of humidity and usage of psychrometric chart

Section A

Introduction to chemical engineering, units and dimensions, conversion of units, dimensional consistency in equations and mole unit, definitions of density, specific gravity, mole and mass fractions, basis, different units of temperature and pressure, limiting and excess reactants, percentage conversion, selectivity & yield, definition and characteristics of a system, difference between open and close systems.

Section B

Material balance: strategy for analyzing material balance problems; solving material balance problems without chemical reactions, solving material balance with chemical reactions, material balances involving multiple subsystem, material balances with recycle and bypass, calculation procedures for ideal gas system; vapor pressure and saturation, calculation of dew point, definition of relative saturation, molal saturation, absolute saturation.

Section C

Energy balance: calculations of enthalpy changes using heat capacity equations and enthalpy tables; use of steam tables; enthalpy balances with chemical reactions, humidity chart and its use in determining the properties of moist air, simultaneous material and energy balances.

Recommended Books:

1. Himmelblau, D. M., & Riggs, J. B. (2009). Basic principles and calculations in chemical engineering. Prentice Hall.
2. Bhatt, B. I., & Vora, S. M. (2004). Stoichiometry. New Delhi: Tata McGraw Hill.
3. Hougen, O. A., Watson, K. M., & Ragatz R.A. (2004). Chemical process principles Part I. CBS Publishers & Distributors Pvt. Ltd.

E-resource(s): https://nptel.ac.in

CHE 204 Heat Transfer

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

The students will be able to:

- Understand and solve conduction, convection and radiation problems
- Design and analyze the performance of heat exchangers, condensers, boilers and evaporators
- Design and analyze reactor heating and cooling system

Section A

Introduction: Modes of heat transfer: conduction, convection, radiation.

Steady-State Conduction in One Dimension: Fourier's Law, thermal conductivity, steady-state conduction of heat through a composite solid, cylinder and sphere; Steady-state heat conduction in bodies with heat sources: plane wall, cylinder and sphere.

Heat Transfer Coefficient: Convective heat transfer and the concept of heat transfer coefficient, overall heat transfer coefficient, heat transfer from extended surfaces, thermal contact resistance, critical insulation thickness, optimum insulation thickness.

Forced Convection: Flow over a flat plate, thermal boundary layer, flow across a cylinder; Dimensional analysis: Buckingham Pi theorem, Dimensional groups in heat transfer; Correlations for the heat transfer coefficient, heat transfer coefficient in a packed and fluidized bed.

Free Convection: Introduction, heat transfer correlations for free convection in flat surface, cylinder, sphere.

Section B

Boiling and Condensation: Boiling phenomenon, nucleate boiling, Correlations for pool boiling heat transfer, critical heat flux, stable film boiling; Forced convection boiling, condensation phenomena, film condensation on a vertical surface, turbulent film condensation, condensation outside a horizontal tube and tube bank; Condensation inside a horizontal tube, effect of non-condensable gases. Drop-wise condensation.

Radiation Heat Transfer: Basic concept, black body radiation, Planck's Law, Wien's Displacement Law, Stefan-Boltzmann Law, Kirchoff's Law, Gray body; Radiation intensity of a black body, spectral emissive power of a black body over a hemisphere. Radiation heat exchange between surfaces- the view factor. Radiation exchange between black bodies and between diffuse gray surfaces.

Section C

Heat Exchangers: Construction of a shell-and-tube heat exchanger, fouling of a heat exchanger, LMTD, temperature distribution in multi-pass heat exchangers, individual heat transfer coefficients; Types of shell-and-tube heat exchanger.

Evaporators: Types, Natural-circulation evaporators, forced-circulation evaporators, falling film evaporators, climbing-film evaporators, agitated

thin-film evaporators and plate evaporators; Principles of evaporation and evaporators; Single and multiple effect evaporators, Capacity and economy, Boiling point rise, heat transfer coefficient enthalpy of a solution; Calculations of a single effect evaporator.

Recommended Books:

1. Kern, D. Q. (2019). Process heat transfer. S.I.: Echo Point Books & Media.
2. Holeman, J. P., & Bhattacharyya, S. (2017). Heat transfer. Chennai: MsGraw Hill Education (India) Private Limited.
3. Chapman, A. J. (1984). Heat transfer. Maxwell Macmillan.
4. Dutta, B. K. (2001). Heat transfer: principles and applications. New Delhi: PHI Learning Pvt. Ltd.

E-resource(s): https://nptel.ac.in

CS 209 Data Structures

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After successful completion of the course, students will be able to:

- Develop knowledge of basic data structures for storage and retrieval of ordered or unordered data. Data structures include: arrays, linked lists, stacks, queues, binary trees, heaps.
- Develop knowledge of applications of data structures including the ability to implement algorithms for the creation, insertion, deletion, searching, and sorting of each data structure.
- Analyze and compare algorithms for efficiency using Big-O notation.
- Describe the concept of dynamic memory management, data types, algorithms, Big O notation.
- Apply Algorithm for solving problems like sorting, searching, insertion and deletion of data.

Section A

Concept of data types, Abstract data type, Data structures, running time of a program, asymptotic notations: Big-Oh, Theta, Little-oh, Omega. Linear data structures: Static implementation of stack, queue, and their applications

Searching and Sorting: Linear search and Binary Search, Bubble sort, Selection sort, Insertion sort, Quick sort, Radix sort.

Section B

Linked List: Linear, doubly or two way, circular, header and various operations; Representation of polynomial using linked list, addition and subtraction of polynomials. Dynamic implementation of stacks and queues. Dynamic memory management: fixed and variable block storage, storage techniques: first-fit, best-fit, worst-fit, next-fit; data compaction, and garbage collection.

Section C

Non linear data structures: Tree concepts, General Tree, binary tree and types, binary search tree, implementation of various operations on Binary Search Tree (tree traversal, searching, insertion and deletion, counting leaf and non-leaf nodes, height), Heap and heap sort, Balanced tree: concepts, rotations, insertion and deletion.

Suggested Books:

1. Langsam, Y., Augenstein, M., & Tenenbaum, A. M. (1996). *Data Structures using C and C++*. New Jersey: Prentice Hall.
2. Tremblay, J. P., & Sorenson, P. G. (1976). *An introduction to data structures with applications.* New York: McGraw-Hill.
3. Horowitz, E., Sahni, S., & Anderson-Freed, S. (2008). *Fundamentals of data structures in C.*Universities Press: Computer Science.
4. Aho, A. V., Hopcroft, J. E., & Ullman, J. D. (1983). *Data Structures and algorithms.* Addison Wesley Publishing Company.

Suggested E-Learning Material:

1. Programming and Data Structures
   https://swayam.gov.in/course/1407-programming-and-data-structures
2. Data Structures and Program Methodology
   https://nptel.ac.in/courses/106103069/

CS 209L Data Structures Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course students will be able to

- Implement problems based on basic data structures like stack and queues.
- Implement problems on linked lists.
- Implement problems for performing different operations like insertion, deletion and searching on binary tree and binary search tree.

Lab Number	**Problems**
L1-L4	Implementation of stack, Applications of stacks (parenthesis checker, postfix evaluation, infix to postfix), recursion
L5-L7	Implementation of linear, circular, circular queue, priority queue
L8-L12	Implementation of linear link list (creation, traversal, insertion, deletion, searching, sorting, merging, reverse)
L13-L14	Implementation of circular link list (creation, traversal, insertion, deletion, searching, sorting)
L15-L16	Implementation of doubly link list (creation, traversal, insertion, deletion, searching, sorting)
L17	Linked representation of stack and queue
L18	Polynomial arithmetic (Addition, Subtraction)
L19-L28	Implementation of binary search tree (creation, traversal, insertion, deletion,searching), Non recursive traversal (inorder, preorder, postorder)
L29-30	Heap creation, insertion, deletion, heap sort

CHE 201 Chemical Engineering Thermodynamics

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

The students will be able to:

- Apply fundamental concepts of thermodynamics to engineering applications.
- Estimate thermodynamic properties of substances in gas and liquid states.
- Determine thermodynamic efficiency of various energy related processes.
- Solve problems related to the solution thermodynamics.

Section-A

Thermodynamics properties of pure fluids: PVT behavior of pure substances, Virial equation of state, the ideal gas, applications of the virial equations, cubic equation of state, generalized correlation for gases and liquids.

Thermodynamics properties of fluids: property relations for homogeneous phases, residual property, residual properties by equations of state, two-phase system, thermodynamic diagram, tables of thermodynamic properties, generalized property correlations for gases, Clapeyron's equation, Kirchoff's equation.

Section-B

Heat effects: sensible heat effects, heat of reaction, formation and combustion, effect of temperature on the standard heat of reaction.

Multi-component systems: fundamental property relation, chemical potential & phase equilibrium, partial properties, ideal-gas mixture, fugacity and fugacity coefficient for pure species & species in solution, generalized correlations for the fugacity coefficient, ideal solution, excess properties: excess Gibbs' energy, activity coefficient.

Phase equilibrium at low to moderate pressures: nature of equilibrium, phase behavior for vapor liquid systems, models for vapor liquid equilibrium: Margules equation, Van Laar equation, NRTL equation, Raoult's Law, Dew point, bubble point and flash point calculations.

Section C

Solution thermodynamics: liquid phase properties from VLE data, models for the excess Gibbs energy, property changes of mixing, heat effects of mixing processes, partially miscible systems.

Chemical reaction equilibrium: reaction coordinates, equilibrium criteria to chemical reactions, standard Gibbs' energy change and the equilibrium constant, effect of temperature on the equilibrium constant, evaluation of equilibrium constants, relations between equilibrium constants and compositions: gas-phase reactions, liquid-phase reactions, calculation of equilibrium compositions for single-phase reactions, multi-component equilibrium.

Recommended Books:

1. Smith, J. M., Van Ness, H. C., & Abbott, M. M. (2005). Introduction to chemical engineering thermodynamics. New York: McGraw-Hill.
2. Rao, Y. V. C. (1997). Chemical engineering thermodynamics. Universities Press.
3. Koretsky, M. D. (2004). Engineering and chemical thermodynamics. New York: Wiley.

E-resource(s): https://nptel.ac.in

CHE 203 Fluid Mechanics

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

The students will be able to:

- Understand the basic principles of fluid mechanics
- Analyze fluid flow problems with the application of the momentum and energy equations
- Analyze pipe flows as well as fluid machinery

Section A

Introduction: unit systems, dimensional consistency, dimensionless groups; hydrostatic forces on submerged objects, buoyancy; continuum hypothesis, definition of a fluid.

Fluid properties: properties of fluids and their classification, Newtonian and Non-Newtonian fluids, types of fluid flow, nature of turbulence, eddy viscosity, flow in boundary layer.

Basic equations of fluid flow: derivation and applications of Navier stokes equation, Bernoulli's equation and Hagen-Poiseuille equation.

Section B

Incompressible flow: Flow in pipes and channels: shear stress and skin friction, friction from changes in velocity or direction, application of Bernoulli's equation for fluid friction; flow in thin layers.

Flow past immersed objects: normal forces in fluids, forces on submerged bodies, motion of single particle through fluid, hindered settling; Flow through bed of solids: packed bed, minimum fluidization velocity.

Section C

Flow measurement: Flow measuring devices for chemical plants: orifice meter, nozzle, venturi meter, rotameter, pitot tube, notches, Hook's experiment.

Flow machinery: classification of pumps; Centrifugal pump: cavitation, net positive suction head, characteristic curves, pump scale-up; application of Bernoulli's equation for pump work; Gas moving machinery: fans, blowers and compressors; work done in isothermal & adiabatic compression.

Agitation of liquids: need; Impellers: propellers, paddles and turbines.

Recommended Books:

McCabe, W. L., Smith, J. C., & Harriott, P. (2005). Unit operations of chemical engineering. Boston: McGraw-Hill.

E-resource(s): https://nptel.ac.in

CS 214 Object Oriented Programming

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After successful completion of the course students will be able to

- Describe the features of C++ supporting object oriented programming.
- Explain the relative merits of C++ as an object oriented programming language.
- Describe how to apply the major object-oriented concepts to implement object oriented programs in C++, encapsulation, inheritance and polymorphism.
- Apply advanced features of C++ specifically stream I/O, templates and operator overloading
- Apply other features of the C++ language including templates, forms of casting, conversions, and file handling.

Section A

Basic Concept of Object Oriented Programming: Need of OOP, advantage over other programming paradigms, Tokens, Keywords, Identifiers and Constants, Basic Data Types, Control Structures.

Functions: Call by Value, Call by Reference, Function Overloading.

Class & Objects: Concepts of Objects & Classes, declaring multiple objects, array of objects, Friend Functions.

Section B

Constructors and Destructors: Introduction, Default, Parameterized and Copy Constructor, Concept and use of destructors.

Operator Overloading: Overloading Unary Operators, Overloading Binary Operators.

Inheritance: Derived and Base Class, Public, Private, Protected, Multiple and Multilevel Inheritance, Function Overriding.

Pointers: Pointers to Objects, this Pointer, Virtual Functions, Polymorphism.

Section C

Console I/O: Concept of Streams, Hierarchy of Console stream Classes, Unformatted and formatted I/O Operations, Managing Output with Manipulators

Templates: Class and function templates, overloading of function templates

File Handling: Classes for file stream operations, open and close a file, EOF, file modes, file pointers and their manipulators, sequential I/O operations, updating a file-Random access, Error Handling During File Operation.

Suggested Books:

1. Balagurusamy, E. (2001). *Object Oriented Programming with C++, 6e*. Tata McGraw-Hill Education.
2. Schildt, H. (2003). *C++: The complete reference*. McGraw-Hill.
3. Lafore, R. (1997). *Object-oriented programming in C++*. Pearson Education.
4. Stroustrup, B. (2000). *The C++ programming language*. Pearson Education India.
5. Venugopal, K. R. (2013). *Mastering C++*. Tata McGraw-Hill Education.

Suggested E-Learning Material:

1. Stroustrup, B. (2000). *The C++ programming language*. Pearson Education India.

   http://www.stroustrup.com/C++.html
2. Programming in C++

   https://nptel.ac.in/courses/106105151/

CS 214L Object Oriented Programming Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

After successful completion of the course students will be able to

- Implement problems based on expressions, arrays and strings.
- Carry out problems using functions, class, constructor and destructor.
- Implement problems using pointers, operator overloading, inheritance, file handling and exception handling.

Lab Number	**Problems**
1-8	Implementation of simple problems with the Objects and class. Understanding of private, public and protected access using problem, Implementation of static variable & static member function.Constructors & destructors. Problems using friend function.
9	Implementation of polymorphism.
10	Implementation of inheritance
11-16	Implementation of operator overloading to overload various operators: unary operators (+, -, *, % etc) and binary operators: +, *, [ ], >> and << operators on vectors
17-18	Problem related with dynamic binding. Problems using this pointer
19-20	Problems related with the templates function and template classes.

CHE 315S Seminar

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

In this course each student will select a topic and give a presentation to the audience.

Learning Outcomes:

The students will be able to:

- Improve communication skills
- Improve presentation of an idea/thought
- Learn about current trends in research, process design and other aspects which may be beyond the boundary of the curriculum

FIFTH AND SIXTH SEMESTER

ECO 307 Fundamentals of Economics

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**0**	**0**	**3**

Learning Outcomes:

Upon Completion of the course student will be able to:

- Understand various aspects of economics that affects the day today functioning of business.
- Understand the oncep[t of demand, supply and production and how the same is related to market.
- Understand the basic financial concepts that affects the functioning of the business.

Section A

What Economics is all about? Micro and Macro Economics.Origin and meaning of Engineering Economics, Role of Economics in Engineering, Scope of Engineering Economics.

Theory of Demand: Law of Demand, Demand Function and Determinants of Demand, Types of Demand.

Elasticity of Demand: Concept, Types and Measurement.

Section B

Production function and Laws of Production.Optimal Input combination. Cost concepts and cost output relationship.

Types of market structures; Determination of equilibrium price and output under perfect competition.

Section C

Timevalue of Money and Project Evaluation: Interest Formulas; Cash Flow Diagram; Principles of Economic Equivalance, Evaluation of Engineering Projects using methods of Present Value and Internal Rate of Return.

Capital Budgeting: Concept and significance of capital budgeting.

Depreciation Analysis: Meaning and causes of depreciation; methods of calculating depreciation – straightline and declining balance methods.

Suggested Readings:

1. Thuesen. G.J., and Fabrycky, N.*Engineering Economy, (9 ed)* PHI Learining Private Limited, New Delhi.
2. S. ParkChan: *Contemporary Engineering Economics:* 3rd Edition, Prentice Hall.
3. M. Parkin: *Economics:* 5th Edition, Addison Wesley.
4. Mahendra P. Agasty: *Engineering Economics and Costing,* Second Edition: Scitech Publications (India) Pvt. Ltd.
5. R. Panneerselvam: *Engineering Economics*, Tenth Printing: PHI Learning Private Limited, New Delhi.

Suggested E learning Material:

1. Agrawal, D. (2017, Mar 8). Indifference Curve. Retrieved from Youtube: https://www.youtube.com/watch?v=3l_rYca4eio.
2. econ (2012). Cost. Retrieved from: Guide:http://www2.econ.iastate.edu/classes/econ301/jintanakul/Notes/Ch7.pdf
3. Khan, Y. (2014, Dec 18). Production Function . Retrieved from Youtube: https://www.youtube.com/watch?v=MwuTt3L2hEQ.
4. Bhogal, S. (2018, June 04). Income and Cross Elasticity. Retrieved from Youtube: https://www.youtube.com/watch?v=i7O4CriwwrY.

MGMT 310 Principles of Management

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**0**	**0**	**3**

Learning Outcome:

Upon completion of the course the student will be able to:

- Evaluate the global context for taking managerial actions.
- Understand conflict resolution, motivation and leadership.
- Understand application of theories and management principles.

Section-A

What is management? Scientific approach-Taylor's contribution, administrative approach-Henry Fayol's contribution, human relation approach-Elton Mayo's contribution, system approach.

Planning: Need and process, types of plans-goals, objectives, policies and strategies; decision making-situations and process.

Section-B

Organizing: Organization structure, departmentation, centralization v/s decentralization, span of management, delegation and power of authority. Motivation-importance, theories of motivation-Maslow, McClleland Herzberg, theories.

Section-C

Theories and styles of leadership-Trait, behavioral.

Communication: Process and principles, types of communication, barriers to communication.

Control: Process of evaluation & control, method of control.

Suggested Reading:

1. Tripathi, P. C., & Reddy, P. N. (2017) Principles of Business Management, (22ed.) Tata McGraw Hill, New Delhi
2. Robbins & D. Cenzo. *Fundamentals of Management (10ed)*, New Delhi, Pearson Education Asia
3. Prasad,L.M.*Principles and practice of Management (9ed)* .Sultan Chand & sons, New Delhi

4. Weihrich&Koonts. *Management-A Global Perspective (13ed)*, Tata McGraw Hill, New Delhi

Suggested E-Learning Material:

1. Prachi, J. (2016). *Planning Function of Management*. Retrieved from Management Study Guide: https://www.managementstudyguide.com/planning_function.htm
2. Amit,L. (2018, December). *Controlling: Features,process and types*. Retrieved from: https://www.youtube.com/watch?v=JRVXfaFrMEM
3. Brian, T. (2017, May 11). *Different Types of Leadership Styles*. Retrieved from: https://www.youtube.com/watch?v=vilZazhIjoc
4. Chandan,P (2017, September 26). *Organising:Meaning,Process and Types*. Retrieved from https://www.youtube.com/watch?v=XrmJG_8d9Cg

MATH 311 Numerical Methods

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

After successful completion of the course students will be able to

- Apply numerical methods to obtain approximate solutions to mathematical problems.
- Analyze and evaluate the accuracy of common numerical methods.
- Solve the nonlinear equations, system of linear equations and interpolation problems using numerical methods with error analysis.
- Examine the appropriate numerical differentiation and integration methods to solve engineering problems.
- Analyze the appropriate numerical method to find the eigen values and corresponding eigenvectors of a system.
- Apply the numerical methods to solve differential equations.

Section A

Errors analysis- Approximations and round off and truncation errors, Root finding for nonlinear equations (transcendental and algebraic equations); Iterative method, Bisection method, Regula-Falsi method, Newton Raphson's method, Order of convergence, Numerical methods for solving system of linear equation, Ill-conditioning.

Section B

Finite differences, Interpolation, Newton's formula for forward and backward interpolation, Newton's general interpolation formula, Lagrange's interpolation formula, Numerical differentiation.

Section C

Numerical integration; Newton's cotes quadrature formula, Trapezoidal, Simpson's rules. Numerical solution of first and second order differential equations, Euler's method, Picard's method, Runge-Kutta's method.

Suggested Books:

1. Rao, K. S. (2006). *Numerical Methods for Scientists and Engineers* (3rd ed.). PHI learning, India.
2. Ramana, B.V. (2015). *Higher Engineering Mathematics* (25th reprint). McGraw Hill.
3. Kreyszig, E. (2011). *Advanced Engineering Mathematics* (9th ed.). Wiley Eastern.

Suggested E-Learning Material:

1. Introduction to Numerical Analysis for Engineering

   https://ocw.mit.edu/courses/mechanical-engineering/2-993j-introduction-to-numerical-analysis-for-engineering-13-002j-spring-2005/index.htm
2. Numerical Analysis

   https://nptel.ac.in/courses/111107062/
3. Elementary Numerical Analysis

   https://nptel.ac.in/courses/111101003/

STAT 204 Probability and Statistical Methods

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

After successful completion of the course students will be able to

- Understand the concepts of random variables, probability distributions and independence of random variables.
- Understand the meaning of probability and probabilistic experiment
- Familiarize with the all approaches to probability theory and particularly, the axiomatic approach.
- Understanding the meaning of conditional probability.
- Distinguish between independent and uncorrelated random variables.
- Distinguish between discrete and continuous random variables and be able to represent them using probability mass, probability density, and cumulative distribution function.
- Identify important types of distributions such as exponential, Binomial, Poisson, Normal, and use them as suitable models in basic science and engineering problems.
- Understand the concept of statistical hypothesis and able to solve such type of real life problems.

Section A

Basic concepts of Probability, Classical, Empirical and Axiomatic approach to Probability. Addition and Multiplication theorems of Probability. Baye's theorem and its simple applications. Marginal, Joint and Conditional probability. Mathematical Expectation: Expectation of sum & products of random variables, Variance & Covariance.

Section B

Correlation & Regression Karl Pearson coefficient of Correlation. Partial and Multiple Correlation (upto three variables only).

Probability Distributions: Binomial, Poisson, Normal, Rectangular & Exponential distributions with simple applications. Fitting of Binomial, Poisson, and, Normal distributions.

Section C

Sampling distribution, Standard Error, Simple random sampling and stratified random sampling with their role. Test of significance for mean, variance, Proportion and correlation coefficient. Test of goodness of fit and independence of attributes. Analysis of variance with one observation per cell.

Suggested Books:

1. Johnson, R. A., Miller, I., & Freund, J. E. (2011). *Probability and Statistics for Engineers*, Prentice Hall.
2. Goon, A. M., Gupta, B. D. & M. K. Gupta.(1980). *Fundamental of Statistics*. (Vol. I & II).The World Press Pvt. Ltd. Kolkata.
3. Mood, A. M., Graybill, F. A., &Boes, D. C. (2001). *Introduction to Theory of Statistics* (3rd ed.). McGraw- Hill International.

Suggested E-Learning Material:

1. Probability and Random variables

   https://ocw.mit.edu/courses/mathematics/18-440-probability-and-random-variables-spring-2014/lecture-notes/
2. Probability and Statistics

   https://nptel.ac.in/courses/111105041/27
3. Statistical Inference

   https://nptel.ac.in/courses/111105043/

CHE 309 Mass Transfer

Max. Marks : 100	L	T	P	C
(CA: 40 + ESA: 60)	3	1	0	4

Learning Outcomes:

The students will be able to:

- Learn about the mass transfer diffusion
- Understand the operations of cooling tower and dryer
- Understand the mechanism of crystallization and absorption
- Understand important parameters and carryout complex calculations involved in a distillation column operation and design

Section-A

Diffusion: Fick's law of diffusion, molecular and eddy diffusion, calculation of diffusivities in gas and liquid, application to diffusion in fluid and solid systems (stagnant film, equimolar, counter, unsteady state).

Convective mass transfer: Mass Transfer coefficients, Laminar and turbulent flow situations and correlations.

Inter-phase mass transfer: film theory , two film theory, penetration and surface renewal theories.

Section-B

Gas absorption: tray and packed columns, choice of solvent and packing arrangements, counter current isothermal, HETP design equation. L/G min, NTU, HTU calculation of NTU, nonisothermal absorption co-current operation.

Adsorption: types of adsorption, nature of adsorbents, Adsorption equilibra; adsorption isotherms and hysteresis; stage wise and continuous contact operations; fixed and moving bed absorbers, adsorption equipments, ion exchange.

Section-C

Humidification: vapor-liquid equilibrium, enthalpy for pure substances, Vapour-gas mixture; absolute humidity, dry bulb temperature, relative and & saturation, dew point, humid volume, humid heat, adiabatic saturation curves, wet bulb temperature; adiabatic gas-liquid contact operation, classification of cooling towers, dehumidification operation.

Drying: Solid-gas equilibria, different modes of drying operations, definition of moisture, mechanism and rate of batch and continuous drying, batch and continuous driers.

Recommended Books:

1. Treybl, R. E. (1980). Mass transfer operations. New York: McGraw Hill.
2. King, C. J. (1971). Separation process. New York: McGraw Hill.
3. Smith, B. D. (1963). Design of equilibrium stage-process. New York: McGraw Hill
4. McCabe, W. L., Smith, J. C., & Harriott, P. (2005). Unit operations of chemical engineering. Boston: McGraw-Hill.
5. Coulson, J. M., & Richardson, J. F. (1990). Chemical engineering. Pergamon.

E-resource(s): https://nptel.ac.in

CHE 312 Chemical Process Control

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

The students will be able to:

- Learn about field instrumentation
- Understand dynamic modeling and behavior of a system
- Understand design of controllers

Section-A

Measurement: Introduction; Classification of Methods of Measurements, Fundamental Methods of Measurement, Factors in Selection of Measuring Instruments.

Measurement System: Purpose and performance of measurement systems, Function of the measurement system, Structure of measurement systems.

Performance characteristics: Static characteristics; Systematic Characteristics; Accuracy, Error, Reproducibility, Range, Span, Ideal

Straight line, Non-linearity, Sensitivity, Environmental effects, Hysteresis, Resolution etc.; Generalized model of a system element and Statistical characteristics.

Dynamic characteristics: Dynamic Response of First and Second order type Instruments with four different types of forcing input functions.

Fundamentals of: Signals acquisition, Conditioning and Processing, Measurement of Temperature, Pressure, Flow, Force and Torque etc.

Section-B

Modeling for Process Dynamics: Concept of Modeling and Simulation, Modeling for Process Dynamics, Mathematical model of physical systems in transfer function.

Linear Open and Closed loop System: Response of First Second and Higher order system, transportation lag, the control system, Closed loop Transfer function, Transient Response of Simple Control System, Stability Analysis, Concept of Root locus.

Frequency Response: Substitution rule, Bode Diagrams Bode stability criteria, Gain & Phase Margin.

Section-C

Controllers: P, PI, PD, PID. Advance Control Strategies: Cascade and Feedforward Control.

Controller Tuning: Ziegler-Nicholes and Cohen and Coon Rules. Controllers using Digital Computer, Introduction to Discrete time Systems, Signals acquisition, Conditioning and Processing.

Control Components: Actuators; valves and servo Amplifier.

Recommended Books:

1. Coughanowr, D. R. (1991). Process systems analysis and control. McGraw Hill.

2. Jain, R.K. (1999). Mechanical & industrial measurements. New Delhi: Khanna Publishers.
3. Stephanopoulos, G. (1984). Chemical process control: An introduction to theory and practice. Pearson
4. Luyben, W. L. (1973). Process modeling, simulation and control for chemical engineers. New York: McGraw Hill.

E-resource(s): https://nptel.ac.in

CHE 320 Mechanical Operations

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

The students will be able to:

- Understand the importance of size reduction and screening operations in mineral industries
- Classify various crushing and grinding units on the basis of working principle
- Select appropriate unit for a particular type of separation

Section-A

Particle technology: particle size, sphericity, shape factor, different ways of expressing particle size, particle size distribution, measurement of average particle diameter; Laws of crushing and grinding; energy required for size reduction, work index; Crushing & grinding equipments; jaw crusher, roll crusher; gyratory crusher, ball mill, hammer mill, fluid energy mill, closed and open circuit grindings; Screens: ideal and actual screens, types of screens, mesh number and size distribution, particle size analysis, effectiveness of screen (screen efficiency); Industrial screening equipments; grizzly, gyratory screen, vibrating screen, trammel; Size enlargement; agglomeration.

Section-B

Solid-Liquid separation: Filtration; principle of cake filtration, equations for compressible and incompressible cakes, constant pressure filtration &

constant rate filtration, filter aid, filter medium, characteristics of filter media; Filtration equipments; filter press, rotary drum and vacuum filter, centrifuges-principles and applications; Gravity based separation sedimentation, clarifier, classifier, thickener, mineral jig, tabling, flotation, hydro-cyclone.

Section-C

Solid-Gas separation: principle and application of cyclone separator and electrostatic precipitator. Storage & conveying of solids: bulk storage, bin storage, hoppers, silos; Conveyors; belt conveyor, chain conveyor, apron conveyor, bucket conveyor, bucket elevator, screw conveyor.

Mixing of solids: application; types of mixers: Muller mixers, ribbon blender, internal screw mixer, tumbling mixer, kneader, Banbury mixer, pug mill.

Recommended Books:

1. McCabe, W. L., Smith, J. C., & Harriott, P. (2005). Unit operations of chemical engineering. Boston: McGraw-Hill.
2. Perry, R. H., Chilton, C. H., & Kirkpatrick, S. D. (1963). Chemical engineers' handbook. New York: McGraw-Hill.
3. Coulson, J. M., & Richardson, J. f. (1990). Chemical engineering. Pergamon
4. Gupta, S. (1979). Momentum transfer operations. New Delhi: Tata Mcgraw-Hill.

E-resource(s): https://nptel.ac.in

CHE 307L Environmental and Fuel Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

The students will be able to:

- Determine different parameters associated with fuel analysis
- Evaluate pollutants quality
- Do sample collection and analysis of data to assess the environmental impact

Environmental Pollution Control

1. pH and TDS measurement for water samples
2. Available chlorine
3. COD measurement
4. BOD measurement
5. DO measurement through aeration unit
6. Air pollution measurement
7. Noise pollution measurement

Fuel Analysis

8. Coal sample analysis
9. Bomb calorimeter
10. Carbon residue
11. Smoke point analysis
12. Flash point measurement
13. Orsat gas analysis
14. Reid vapor pressure

Note: Minimum five experiments from each subject are compulsory.

CHE 318L Fluid Mechanics and Mechanical Operations Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Objectives:

The students will be able to:

- Test basic concepts of fluid flow and calculate important parameters for given systems
- Carryout size analysis of a given sample and select appropriate unit for size reduction
- Classify various crushing and grinding units on the basis of working principle

- Select appropriate unit for a particular type of separation

Fluid Mechanics

1. Pressure drop due to various kind of fittings
2. Drag coefficient measurement
3. Bernoulli's theorem
4. Flow measurement through pressure drop
5. Fluidized bed
6. Centrifugal pump test rig (constant speed)
7. Centrifugal pump test rig (variable speed)

Mechanical Operations

8. Gyratory sieve shaker with test sieves
9. Ball mill (constant speed)
10. Ball mill (variable speed)
11. Roll crusher
12. Jaw crusher
13. Cyclone separator
14. Mineral Jig

Note: Minimum five experiments from each subject are compulsory.

CHE 313L Process Simulation Lab-I

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

The students will be able to:

- Handle simulation software
- Select and implement appropriate theoretical model
- Solve the process flow diagram using simulation software
    1. CFD
    2. ASPEN

CHE 303 Chemical Reaction Engineering

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

The students will be able to:

- Analyze chemical reactors and reaction systems
- Solve open-ended reaction engineering problems in teams
- Calculate operating parameters for isothermal and non-isothermal operation of ideal well-mixed batch and continuous reactors, and for ideal plug-flow reactors
- Formulate a set of consistent material and energy balance equations to describe operation of batch, semi-continuous and continuous reactor systems with single or multiple reactions, operating with and without heat exchange
- Choose an appropriate reactor type and operating conditions to achieve a desired output such as reactant conversion, selectivity and yield

Section-A

Introduction: Definition of reaction rates, variables affecting reaction rates, classification of reactions, order, molecularity. Kinetics of Homogenous Reactions: Concentration & temperature dependent term of a rate equation.

interpretation of batch reactor data & reactor design: Constant volume batch reactor, variable volume batch reactor, temperature and reaction rate; Reactor Design: Ideal batch reactor, steady state Mixed Flow Reactor, steady state PFR, Holding time and space time for flow systems.

Section-B

Design for single reactions: Size comparison, multiple reactor systems, recycle reactor, auto catalytic reactions.

Design for parallel reactions: Irreversible first order reactions in series, first order followed by zero order & zero order followed by first order reactions, reversible reaction, irreversible series-parallel reactions.

Non-isothermal reactor design: Design for adiabatic batch and flow reactors, Non-adiabatic maxed flow reactor, Multiple steady-states in a mixed flow reactor; Single reactions and multiple reactions & selection of reactors.

Section-C

Non-Ideal Flow: Residence time distribution of fluids, General characteristics, Measurement of RTD, RTD in Ideal Reactor, Dispersion Model, Tanks-in Series Model, Chemical Reaction and conversion using RTD data directly as well as using dispersion and tanks-in-series models.

Recommended Books:

1. Levenspiel, O. (1999). Chemical reaction engineering. Singapore: John Wiley & Sons.
2. Scott Fogler, H. (2015). Elements of chemical reaction engineering. Delhi: Prentice Hall.
3. Smith, J. M. (1981). Chemical engineering kinetics. McGraw-Hill.

E-resource(s): https://nptel.ac.in

CHE 305 Chemical Technology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

The students will be able to:

- Understand important process industry in Chemical Engineering
- Understanding of basic operations involved
- Identify important aspects of a process flow diagram

Section-A

Industrial Gases: Hydrogen, oxygen, nitrogen, producer gas and water gas.

Fertilizer Industries: Nitrogen, potassium and phosphorus based fertilizers.

Agrochemicals: Important pesticides, BHC, DDT.

Cement Industries: Types and manufacture of Portland cement.

Coal Chemicals: Coal tar distillation and recovery of chemicals.

Industrial Acids: Sulfuric acid and nitric acid.

Chlor Alkali Industry: Sodium carbonate, caustic soda, chlorine.

Section-B

Petroleum Industries: Origin, refining, cracking, reforming, alkylation and isomerization.

Petrochemical Precursors: Formaldehyde, acetaldehyde, acetic acid, acetic anhydride, maleic anhydride, nitrobenzene, ethylene oxide, ethylene glycol, acrylonitrile, styrene, butadiene.

Oils and Fats: Refining of edible oils and fats, fatty acids, hydrogenation of oils, soaps and detergents.

Pulp & Paper Manufacturing: kraft process, production & engineering problems, paper products, viscose staple fibre.

Section-C

Sugar and Alcohol Industries: Manufacturing of sugar, Fermentation of industrial alcohol, absolute alcohol, ethyl alcohol, beers, wines and liquors.

Polymer Based Industries and Their Characteristics: Plastics, Production of thermoplastic and thermosetting resins such as polyethylene, polypropylene, phenolic resins and epoxy resins, polymers and their applications in engineering practice.

Recommended Books:

1. Rao, M. G., & Sittig, M. (1997). Dryden's outlines of chemical technology. East-West Press Private Ltd.
2. Austin, G. T. (1984). Shreve's chemical process industries. McGraw Hill.

E-resource(s): https://nptel.ac.in

CHE 311 Plant Design and Economics

Max. Marks : 100	L	T	P	C
(CA: 40 + ESA: 60)	3	1	0	4

Learning Outcomes:

The students will be able to:

- Understand concepts of process design and project management
- Synthesize feasible and optimum flow-sheet
- Design of energy integration of process (or heat exchanger network in the process)
- Estimation of capital investment, total product costs and profitability
- Optimum design of equipments based on economics and process considerations

Section-A

The Design Process: Design Opportunities. Steps in Process Design, Environmental Protection, Safety Considerations.

Process Creation: Preliminary Database Creation, Experiments, Preliminary Process Synthesis, Development of the Base Case Design.

Simulation to Assist in Process Creation: Principles of Steady-State Flowsheet Simulation, Principles of Batch Flowsheet Simulation.

Heuristics for Process Synthesis : Introduction, Raw Materials and Chemical Reactions, Distribution of Chemicals, Separations, Heat Removal from and Addition to Reactors, Heat Exchangers and Furnaces, Pumping, Compression, Pressure Reduction Vacuum and Conveying of Solids, Changing the Particle Size of Solids, Removal of Particles from Gases and Liquids.

Section-B

Energy Integration : Introduction, Minimum Utility Targets, Networks for maximum Energy Recovery, Minimum Number of heat Exchangers, Threshold Approach Temperature, Optimum Approach Temperature, Superstructures for minimization of annual costs, Multiple Utilities, Distillation Trains, Heat Engines and Head Pumps.

Scheduling of Batch Processes: Design of single and multiple product processing sequences.

Section-C

Cost Accounting and Capital Cost Estimation: Accounting, Cost Indexes and Capital Investment for Commodity Chemicals, Capital Investment Costs, Estimation of the Total Capital Investment, Purchase Costs of the Most Widely Used Process Equipment.

Annual Costs, Earnings and Profitability Analysis : Introduction, Annual Sales Revenues, Production Costs and The Cost Sheet, Working Capital and Total Capital Investment, Approximate Profitability Measures, Time Value of Money, Cash Flow and Depreciation, Rigorous Profitability Measures.

Recommended books:

1. Seider, W.D., Seader, J.D. & Lewin, D.R. (2012). Product & process design principles. Wiley India.
2. Smith, R., & Smith, R. (1995). Chemical process design. New York: McGraw-Hill.
3. Coulson, J. M., Sinnott, R. K., & Richardson, J. F. (1989). Chemical engineering. Volume 6: An Introduction to Chemical Engineering Design. Oxford: Pergamon.

E-resource(s): https://nptel.ac.in

CHE 319L Heat and Mass Transfer Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

The Students will be able to:

- Calculate important parameters involved in various modes of heat transfer and determine effect of operating/design variables on heat transfer
- Calculate various important parameters involved in mass transfer and determine effect of operating/design variables on mass transfer

Heat Transfer

1. Fin tube heat exchanger
2. Shell and Tube heat exchanger
3. Vertical and horizontal condenser
4. Heat transfer in agitated vessel

5. Heat Transfer through composite wall
6. Natural convection heat transfer
7. Forced Convection heat transfer

Mass Transfer

8. Steam distillation
9. Continuous packed bed distillation
10. Forced draft tray dryer
11. Solid-gas diffusion
12. Adsorption in packed bed
13. Vapor-liquid equilibria
14. Liquid-liquid extraction

Note: Minimum five experiments from each subject are compulsory.

CHE 321L Reaction Engineering and Process Control Lab

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

The Students will be able to:

- Calculate reaction kinetics parameter using various techniques
- Compare performance of various types of reactor and select appropriate reactor and configuration of reactors
- Model physical systems
- Operate control systems
- Design and tune control systems for typical chemical processes

Reaction Engineering

1. Study of rate law parameters
2. Reactors in series
3. Isothermal batch reactor
4. Continuous stirred tank reactor
5. RTD studies in plug flow reactor
6. Plug flow reactor (coil type)

7. Plug flow reactor (straight tube)

Process Control

8. Interacting and non-interacting systems
9. Time constant of thermocouple and thermometer
10. Time constant of manometer
11. Trainer for temperature control
12. Trainer for pressure control
13. Trainer for level control
14. Trainer for flow control

Note: Minimum five experiments from each subject are compulsory.

CHE 314L Process Simulation Lab-II

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**4**	**2**

Learning Outcomes:

The students will be able to:

- Handle simulation software
- Select and implement appropriate theoretical model
- Solve the process flow diagram using simulation software
  1. CFD
  2. ASPEN

SEVENTH AND EIGHT SEMESTER

CHE 308 Environmental Pollution Control

	L	T	P	C
Max. Marks : 100				
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:
The students will be able to:

- Understand direct and indirect impact on human health
- Understand methods to reduce pollution
- Do waste management and utilization

Section-A

Introduction: Legislation, standards for water and air. Effects of air pollutants on human health, vegetation and materials. Wastewater Treatment: Characterization of Industrial wastewater, primary, secondary and tertiary treatment, segregation, screening, equalization, coagulation, flocculation, precipitation, flotation, sedimentation, aerobic treatment, anaerobic treatment, absorption, ion exchange, membrane filtration, electro-dialysis, sludge dewatering and disposal methods.

Section-B

Air Pollution Control: Sources and classification of air pollutants, nature and characteristics of gaseous and particulate pollutants, pollutants from automobiles. Air pollution meteorology, plume and its behavior and atmospheric dispersion, control of particulate emissions by gravity settling chamber, cyclones, wet scrubbers, bag filters and electrostatic precipitators.

Section-C

Control of gaseous emissions by absorption, adsorption, chemical transformation and combustion. Solid Waste Management: Hazardous and non-hazardous waste, methods of treatment and disposal, land filling, leachate treatment and incineration of solid wastes.

Recommended Books:

1. Peavy, H. S., Rowe, D. R. Tchobanoglous, G. (1995). Environmental engineering. McGraw Hill.
2. Modi, P. N. (2001). Sewage treatment & disposal and waste water engineering. Standard Book House, Delhi.

3. Tchobanoglous, G., Burton, F. L., Stensel, H. D., & Metcalf & Eddy. (2003). Wastewater engineering: Treatment and reuse. Boston: McGraw-Hill.

CHE 402 Chemical Plant Simulation

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

The students will be able to:

- Understand the stages involved in the development of a process model
- Formulate a chemical engineering problem as a mathematical model from basic engineering principles
- Identify the appropriate numerical solutions used in solving the models
- Apply various simulation tools for solving the chemical engineering models developed

Section-A

Introduction to Modeling and Simulation. Analysis of Models: Role of analysis, basic concepts of analysis, the analysis process, simple examples, source of model equations, conservation equations of mass, energy and momentum, constitutive equations, control volume, dimensional analysis, stability analysis, sensitivity analysis.

Section-B

Formulation of Process Models: Development of model equations for simple isothermal non-reacting and reacting liquid systems for both steady state and unsteady state conditions, isothermal two phase systems and rate of mass transfer, equilibrium staged processes, nonisothermal systems.

Section-C

Modeling of distillation column, absorber, heat exchanger, heat transfer in a jacketed vessel. Chemical Process Simulation: Introduction to simulation methodologies, process flowsheet simulators.

Recommended books:

1. Fisher, R. J., & Denn, M. M. (1976). *Introduction to chemical engineering analysis*. John Wiley.

2. Babu B.V. (2008). *Process plant simulation*. Oxford University Press.
3. Biegler, L. T., Grossmann, I. E., & Westerberg, A. W. (1997). *Systematic methods for chemical process design*. Prentice Hall.

CHE 411 Process Plant Safety and Hazard Analysis

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

The students will be able to:

- Students will be provided the guidance to key techniques and methods used in industry for identifying and documenting safety and health hazards and their controls.
- It also contains examples that explain how to identify hazards, analyze hazards and controls, document the results of an analysis, and manage residual risk

Section-A

Introduction: Safety program, engineering ethics, accidents & loss statistics, acceptable risk, public perception, three significant disasters: case studies.

Toxicology: Toxic materials and their properties, effect of dose and exposure time, relationship and predictive models for response, threshold limit value and its definitions, industrial hygiene evaluation.

Section-B

Fire & Explosion: The fire triangle, distinction between fires and explosions, definitions, flammability characteristics of liquids and vapors, minimum O2 concentration & inerting, ignition energy, autoignition, autooxidation, ignition sources, explosions.

Introduction to Reliefs: relief concepts, definitions, location, types, relief scenarios, relief systems.

Section-C

Hazard Identification: process hazard checklist, surveys, hazard & operatibilty studies (HAZOP).

Risk Assessment: probability and failure, plant reliability, risk analysis, event trees & fault trees.

Accident Investigations: learning from accidents, layered investigation, aids for diagnosis, aids for recommendations.

Recommended books:

1. Crowl, D. A., & Louvar, J. F. (2001). *Chemical process safety: Fundamentals with applications*. Pearson Education.
2. Wentz, C. A. (1998). *Safety, health, and environmental protection*. McGraw-Hill Companies.
3. Smith, B. D. (1963). *Design of equilibrium stage processes*. McGraw-Hill Companies.

E-resource(s): https://nptel.ac.in

DISCIPLINE ELECTIVES

CHE 401 Biochemical Engineering

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

The students will be able to:

- Kinetics of enzymatic reactions
- Understand about metabolic stoichiometry and energetic
- Design and analysis of biological reactors
- Do economic analysis bioprocess

Section-A

Overview of Biochemical Engineering with emphasis on cell structure and cell types.

Chemicals of life: structural and functional characteristics of RNA, DNA and proteins.

Kinetics of enzymatic reactions: enzyme commission classification system, Michaelis-Menten kinetic model, factors affecting enzyme kinetics, enzyme reactions in heterogeneous system, application of enzyme in industries.

Section-B

Metabolic stoichiometry and. energetic: Thermodynamic principles, coupling by ATP and NAD, Embden-Meyerhof- Parna pathway, TCA cycle, electron transport and phosphophorylation, transport across cell membranes.

Molecular genetics and control: gene expression, alteration of cellular DNA, recombinant DNA technology.

Biomass production: Monod growth curve and forms, growth cycle phases for batch cultivation.

Transport phenomena in bioprocess: basic mass transfer concepts, rates of metabolic oxygen utilization, factors affecting mass transfer.

Section-C

Design and analysis of Biological reactors: fermentation technology for a medium formulation, environmental requirements for animal cell cultivation, plant cell cultivation.

Product recovery: commercial enzymes, antibiotics, organic acids, ethanol and single cell protein.

Bioprocess economics: bio-products regulations and general fermentation process economics with example.

Recommended Books:

1. Bailey, J. E., & Ollis, D. F. (1986). Biochemical engineering fundamentals. New York: McGraw Hill Publishing Company.
2. Wiseman, A. (1985). Handbook of enzyme biotechnology. E. Horwood.
3. Schomburg, D., Stephan, D., & Gesellschaft für Biotechnologische Forschung (Braunschweig, Germany). (1996). Enzyme handbook: 12. Berlin: Springer.
4. Pye, E. K, & Wingard, L. B. (1974). Enzyme engineering: 2. New York: Plenum Press.
5. Palmer, T., & Bonner, P. L. (2007). Enzymes: biochemistry, biotechnology, clinical chemistry. Elsevier.

E-resource(s): https://nptel.ac.in

CHE 409 Petroleum Refining Technology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Objectives:

The students will be able to:

- Introduction with the petroleum refinery worldwide
- Develop knowledge of different refining processes
- Develop knowledge of safety and pollution control in the refining industries.
- To find the suitable refining technology for maximizing the gasoline yield

Section-A

Introduction: History & Development of Refining, petroleum industry in India, origin, exploration, drilling and production of petroleum crude, Composition and classification of petroleum crude, Laboratory test

methods,. Petroleum products – LPG, Gasoline, naphtha, kerosene, diesel oil, lubricating oil, wax etc.

Section-B

Transportation & pretreatment of petroleum products, Separation Processes: Design and operation of topping and vacuum distillation units. Solvent extraction processes for lubricating oil base stocks and for aromatics from naphtha and kerosene, solvent dewaxing.

Section-C

Conversion Processes: Thermal and catalytic cracking, vis-breaking and coking processes, reforming, hydro processing, alkylation, polymerization and isomerisation. Corrosion control in refining processes.

Recommended books:

1. Prasad, R. (2007). *Petroleum refining technology*. Khanna Publishers.
2. Nelson, W. L. (1985). *Petroleum refinery engineering*. Auckland: McGraw-Hill.

E-resource(s): https://nptel.ac.in

CHE 410 Polymer Science and Technology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Objectives:

The students will be able to:

- Comprehend basics of polymer science
- Students would learn concept of average molar masses and molar mass distributions
- Students would be introduced elastomers, plastics and fibers that are used in the industry
- Students would learn fundamentals of Step-growth polymerization
- Students would learn fundamentals of Chain/addition polymerization-ionic and free radical polymerization

Section-A

Polymerization Chemistry: Chain, step and miscellaneous polymerization reactions and polymerization technique. Polymerization kinetics: Free radical, cationic and anionic polymerization, polycondensation, polymerization. Polymerization Processes: Bulk, solution, emulsion and suspension polymerization.

Section-B

Molecular Weight Estimation: Average molecular weight: number average and weight average molecular weights. Thermoplastic composites, fiber reinforcement fillers, surface treatment reinforced thermo set composites - Resins, Fibers, additives, fabrication methods.

Section-C

Manufacturing processes of important polymers: Plastics- polyethylene, polypropylene, polyvinyl chloride & copolymer, polystyrene; Urea-formaldehyde, Teflon, elastomers, rubbers, polyamides (6:6 Nylon), Polyesters (Dacron).

Recommended books:

1. Gowariker, V. R., Viswanathan, N. V., & Sreedhar, J. (1986). *Polymer science*. New Age International.
2. Rodriguez, (1970). *Principles of polymer science*. Tata McGraw Hill.
3. David, J. W. (1971). *Polymer science and engineering*, Prentice Hall

E-resource(s): https://nptel.ac.in

CHE 414 Advanced Heat Transfer

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

The students will be able to:

- Understand flow behaviour in boundary layers
- Do analogs study between heat, mass and momentum
- Recognize factors affecting during transport of mass and energy
- Do make energy balances in boundary layers

Section-A

Introduction; molecular momentum transport; convective momentum transport; velocity distribution in laminar flow; Equations of change for isothermal systems; Equations of change, applications of equations of change; velocity distribution with more than one independent variables, stream functions and velocity potential, flow near solid surfaces, molecular energy transport, convective energy transport.

Section-B

Energy balances; convection; equation of change for non-isothermal systems; applications of equations of change; temperature distribution with more than one independent variable; molecular mass transport; convective mass transport; mass balances; concentration distribution in solids and laminar flow.

Section-C

Concentration distribution with more than one independent variable: boundary layer theory, turbulent flow, velocity distribution in turbulent flow; temperature distribution in turbulent flow; concentration distribution in turbulent flow.

Recommended Books:

1. Bird, R. B., Stewart, W. E., & Lightfoot, E. N. (2007). *Transport phenomena*. John Wiley & Sons.
2. Deen, W. M. (1998). *Analysis of transport phenomena* (Vol. 2). New York: Oxford University Press.
3. Welty, J. R., Wicks, C. E., Rorrer, G., & Wilson, R. E. (2009). *Fundamentals of momentum, heat, and mass transfer*. John Wiley & Sons.

E-resource(s): https://nptel.ac.in

CHE 304 Advanced Chemical Reaction Engineering

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

The students will be able to:

- Understand mechanism of catalytic reactions and analysis of kinetic data
- Understand yield and selectivity of reaction and diffusion in porous catalyst
- Design catalytic reactors
- Understand rector design for different type of reactions

Section-A

Catalysts: Description, methods of preparation and manufacture; catalyst characterization BET surface grea, pore volume pore size distribution. catalyst Reaction Kinetic Models : Physical and chemical adsorption; Determination of rate expressions using adsorption, surface reaction and desorption as rate-controlling steps.

Determination of Global Rate of Reaction: Heterogeneous laboratory reactors; Determination of rate expressions from experimental data. Effect of Intrapellet Diffusion on Reaction Rates in Isothermal Pellets: concept of effectiveness factor, Thiele modulus, experimental determination of effectiveness factor-Weisz- Prater criteria, Non-isothermal effectiveness factor.

Section-B

Packed bed catalytic reactors: suspended solid reactors, bubbling fluidized bed and circulating fluidized bed reactors.

Deactivating Catalyst: mechanism of deactivation, rate & performance equations.

Gas-Liquid Reactions on solid catalyst: trickle bed, slurry reactors, three-phase fluidized beds, general rate equations & performance equations

Section-C

Non-catalytic systems: rate equations for fluid-fluid reactions, reactor design;

Fluid particle reaction kinetics: selection of a model, shrinking core model for spherical particle of unchanging size, rate equation and determination of the rate controlling step. Fluid–particle reactors design.

Recommended Books:

1. Levenspiel, O. (1999). Chemical reaction engineering. Singapore: John Wiley & Sons.
2. Scott Fogler, H. (2015). Elements of chemical reaction engineering. Delhi: Prentice Hall.
3. Smith, J. M. (1981). Chemical engineering kinetics. McGraw-Hill.

E-resource(s): https://nptel.ac.in

CHE 317 Advanced Mass Transfer

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

The students will be able to:

- Understand concepts of distillation, liquid-liquid extraction, leaching and crystallization
- Carryout calculations involved in design of distillation, liquid-liquid extraction, leaching and crystallization units using various methods used in industries

Section-A

Distillation: Vapor-liquid equilibria: pressure-temperature-concentration phase diagram, enthalpy-concentration diagram; ideal and non-ideal solutions, Raoult's law and its application, relative volatility, maximum and minimum boiling mixtures.

Single stage binary distillation: flash vaporization, partial condensation, differential (Rayleigh) distillation, differential condensation, constant relative volatility, lever rule, steam distillation.

Section-B

Continuous distillation of binary mixtures: ideal and non-ideal stages, definition of a point, stage and column efficiency; Ponchon Savarit method: adiabatic & non-adiabatic; McCabe Thiele method: plate calculations, feed plate location; use of open steam, tray efficiency, tray type (bubble cap, sieve & valve), flooding, tray layout, delta P, tray hydraulics, determination of column height and diameter; packed column.

Liquid-liquid extraction: principle, usefulness, ternary liquid equilibria, triangular coordinates, mixer rule, choice of solvent; Extractors: mixer settlers, spray & packed column, rotating disk contactor, sieve tray column.

Section-C

Leaching: solid liquid equilibrium; Batch and continuous operations: single and multistage cross current and counter current operations, number of equilibrium stages; Equipments: percolation tank, agitated vessel, thinkers, classifiers, continuous counter current decantation.

Crystallization: nucleation & crystal growth rate, controlled growth of crystals, equilibrium yield of crystallization, heat and mass transfer rates in crystallization, classification of industrial crystallizers.

Recommended Books:

1. Treybal, R. E. (1980). Mass transfer operations. New York: McGraw-Hill Book Company.
2. King, C. J. (2013). Separation processes. Courier Corporation.
3. Smith, B.D. (1963). Design of equilibrium stage process. Ney York: McGraw-Hill.
4. McCabe, W. L., Smith, J. C., & Harriott, P. (2004). Unit operations of chemical engineering. 7th ed. New York: McGraw-Hill.
5. Coulson, J. M., & Richardson, J. F. (1990). Chemical engineering. Pergamon.

E-resource(s): https://nptel.ac.in

CHE 310 Optimization of Chemical Processes

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

The students will be able to:

- Apply the knowledge of optimization to formulate the problems
- Apply different methods of optimization and to suggest a technique for specific problem with a single variable
- Apply different methods of optimization and to suggest a technique for specific problem with multivariable
- Apply of simplex method for linear optimization problems

- Understand how optimization can be used to solve the industrial problems of relevance to the chemical industry

Section-A

Introduction to process optimization: Formulation of various process optimization problems, Basic concepts of optimization: convex and concave functions, necessary and sufficient conditions for stationary points. **Unconstrained single variable optimization:** Newton, Quasi-Newton methods, Polynomial approximation methods. **Unconstrained multivariable optimization:** Direct search methods, conjugate search method, steepest descent method, conjugate gradient method, Newton's method.

Section-B

Linear Programming with constraints: Formulation of LP problem, graphical solution of LP problem, simplex method, duality in linear Programming, Two-phase method.

Section-C

Non-linear programming with constraints: Necessary and sufficient conditions for a local extremum, Penalty & Barrier methods, Quadratic Programming, successive quadratic programming, Generalized reduced gradient (GRG) method.

Recommended books:

1. Edgar, T. F., Himmelblau, D. M., & Lasdon, L. S. (2001). Optimization of chemical processes. McGraw-Hill,.
2. Rao, S. S. (1985). Optimization Theory and Applications. New Delhi: Wiley Eastern.

E-resource(s): https://nptel.ac.in

CHE 408 Nano-Science and Technology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Objectives:

The students will be able to:

- Demonstrate the understanding of length scales concepts, nanostructures and nanotechnology
- Identify the principles of processing, manufacturing and characterization of nanomaterials and nanostructures
- Apply the electronic microscopy, scanning probe microscopy and nano-indentation techniques to characterize the nano-materials and nanostructures
- Evaluate and analyze the mechanical properties of bulk nanostructured metals and alloys, nano-composites and carbon nano-tubes

Section-A

Supramolecular chemistry: Definition and examples of the main intermolecular forces used in supramolecular chemistry. Self-assembly processes in organic systems.

Basic principles and fundamental properties: Size and Confinement Effects, Nanoparticle Morphology, Physical and Chemical Properties.

Section-B

Synthesis of nanomaterials: Introduction to nanomaterials, Equipment and processes needed to fabricate nano devices and structures such as bio-chips, power devices and opto-electronic structures. Top-down (Nanolithography, CVD), Bottom-up (Sol-gel processing, chemical synthesis). Wet deposition techniques, Self-assembly (Supramolecular approach).

Section-C

Different classes of nanomaterials: Metal and Semiconductor Nanomaterials, Quantum Dots, Wells and Wires, Molecule to bulk transitions Bucky balls and Carbon Nanotubes.

Instrumentation for nanoscale characterization: TEM, SEM and SPM technique, Fluorescence Microscopy and Imaging.

Recommended books:

1. Steed, J. W., & Atwood, J. L. (2013). *Supramolecular chemistry*. John Wiley & Sons.
2. Bréchignac, C., Houdy, P., & Lahmani, M. (Eds.). (2008). *Nanomaterials and nanochemistry*. Springer Science & Business Media.
3. Lehn, J. M. (1995). *Supramolecular chemistry* (Vol. 1). Germany: Vch, Weinheim.

E-resource(s): https://nptel.ac.in

CHE 406 Food Processing and Engineering

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcomes:

The students will be able to:

- Understand the importance of food processing
- Identify process conditions for food processing
- Carryout food processing at ambient temperature
- Select suitable medium such as heat, air, oil etc. for food processing
- Identify post processing operations for storage and distribution

Section-A

Introduction to food processing; properties of foods & processing theory: Units and dimensions: Density and specific gravity, fluids viscosity, rheology and texture, surface properties, thermodynamies of food, heat changes, mass transfer.

Ambient temperature processing: Raw material preparation : cleaning, sorting, grading and peeling; size reduction of solid and liquid food; mixing and forming; separation and concentration of food components; fermentation and enzyme technology; Irradiation; Processing using electric field, high hydrostatic pressure. light or ultrasound.

Section-B

Processing by application of heat: Blanching; Pasteurization; Heat Sterilization; Evaporation and distillation; Extrusion.

Processing using hot air: Dehydration, Baking and Roasting.

Processing using hot oil: Frying

Processing by direct and radiated energy: Dielectric, ohmic and infrared heating.

Section-C

Processing by removal of heat: Chilling, Freezing, Freeze-drying and freeze concentration Minimal Processing methods under Develpment.

Post-Processing operations: Coating or Enorbing; Packaging; Filling and Sealing of containers; materials handling storage and distribution.

Recommended books:

1. Fellows, P. J. (2009). Food processing technology: principles and practice. Elsevier.
2. Lewis, M. J. (1990). Physical properties of foods and food processing systems. Elsevier.
3. Toledo, R. T. (1997). Fundamentals of food processing engineering. Chapman & Hall.
4. Subbulakshmi, G., & Udipi, S. A. (2007). Food processing and preservation. New Age International.

E-resource(s): https://nptel.ac.in

CHEM 301 Analytical Techniques

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**3**	**1**	**0**	**4**

Learning Outcome:

On completion of course, the students will be able to:

- understand the principle and various types of chromatography.
- understand and apply the concept and application of electrophoresis.
- understand the principles of NMR, UV-visible and IR spectroscopy.
- perform theoretical calculations related to the techniques discussed.

Section-A

Measurement of pH: Determination of pH, ion selective electrode, nstrumentation, applications.

Conductometric Measurements: Definitions, relations & laws, effect of dilution, conductance measurements, and applications; Conductometric titrations: types, advantages and disadvantages.

Fluorimetry and Phosphorimetry: Introduction, comparison of absorption and fluorescence methods, theory, instrumentation, applications of fluorimetry and phosphorimetry, comparison of fluorimetry and phosphorimetry, comparison of fluorimetry and phosphorimetry with absorption methods.

Section-B

Principles and Applications of Chromatographic Techniques: Thin Layer Chromatography, Paper Chromatography, Column Chromatography

Gas Chromatography: Introduction, principles, instrumentation, apparatus and materials, retention volume, resolution, applications.

High Performance (Pressure) Liquid Chromatography: Introduction, principle, instrumentation, apparatus and materials, column efficiency and selectivity, comparison with gas-liquid chromatography, applications.

Electrophoresis: Introduction, principle, types, applications.

Section-C

UV spectroscopy: The nature of electronic excitation, the origin of UV band structure; chromophores, Auxochromes, effects of conjugation and geometry; Calculation of lamda maxima, effect of solvents, qualitative and quantitative applications.

1R Spectroscopy: The IR absorption process; the modes of vibrations, coupled interactions, hydrogen bonding. The Hook's law, radiation source, sample handling, qualitative and quantitative applications.

Nuclear Magnetic Resonance Spectroscopy: Principles, Instrumentation techniques; Shielding and deshielding of magnetic nuclei, chemical shift and its measurements, factors influencing chemical shifts, spin-spin interaction, factors influencing coupling constant 'J', Applications.

Recommended Books:

1. Christian ,G. D., *Analytical Chemistry*, John Wiley; 6th Edition.
2. Skoog, D.A., West, D.M., Hollar, F.J.& Crouch S.R.; *Fundamentals of Analytical Chemistry,* Cengage learning; 9 Ed.

3. .Willard, H. L., Merritt, L. , Dean, J.A. & Settle, F.A.(2004) *Instrumental methods of Analysis*; HCBS Publishing New Delhi: 7th Ed.
4. Ewing, G. W. Ewing, *Instrumental Methods of Chemical Analysis*, McGraw-Hill Int 5th Ed.
5. .Holler, F. J., Skoog, D. A. & Crouch, S. R. *Priniciples of Instrumental Analysis*, Thomson Books/Cole , 6thEd.
6. Mendham, J., Denney, R.C. , Barnes ,J.D. & Thomas, M. *Text Book of Quantitative Inorganic Analysis*, Pearson Education Asia,6th Ed.
7. Willard, H.H., Merritt, J.A. Dean, L.L. & Settle, F.A. *Instrumental Methods of Analysis*, CBS Publishing New Delhi, 7th Ed.

Suggested e-Sources:

1. National Programme on Technology Enhanced Learning https://nptel.ac.in
2. Online Chemistry Courses https://www.edx.org/learn/chemistry
3. Free Online Education SWAYAM https://swayam.gov.in

MCTR 403 Robotics and Automation

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

After successful completion of the course students will be able to

- Develop skills of creating industrial and mobile robot projects
- Implement robots like KUKA, PUMA in real industrial world
- Create innovative robot designs using mathematical concepts of kinematics
- Develop autonomous mobile robots in surveillance, security, home and office services.

Section A

Basic Concepts - Automation and Robotics – An over view of Robotics – present and future applications – classification by coordinate system and control system, Dynamic stabilization of Robotics.

Power Sources and Sensors- Hydraulic, Pneumatic and electric drivers – Determination HP of motor and gearing ratio, variable speed arrangements,

Path Determination - Machinery Vision – Ranging – Laser – Acoustic, Magnetic Fiber Optic and Tactile Sensor.

Section B

Manupulators - Construction of Manupulators, Manupulator Dynamic and Force Control, Electronic and Pneumatic manupulators.

Acuators and Grippers - Pneumatic, Hydraulic Actuators, Stepper Motor Control Circuits, End Effecter, Various types of Grippers, Design consideration.

Differential transformation and manipulators, Jacobians – problems.Dynamics: Lagrange – Euler and Newton – Euler formations – Problems.

Section C

Kinematics - Forward and Inverse Kinematic Problems, Solutions of Inverse Kinematic problems, Multiple Solution, Jacobian Work Envelop – Hill Climbing Techniques.

Path Planning - Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion – straight line motion – Robot programming, languages and software packages.

Case Study - Multiple Robots – Machine Interface – Robots in Manufacturing and Non-Manufacturing applications – Robot Cell Design Selection of a Robot.

Suggested Books:

1. Groover,M. P.(2017). *Industrial Robotics: Technology, Programming, and Applications* (2nded.). Pearson Education.
2. Niku, S. B. (2011). *Introduction to Robotics* (2nded.). Wiley.
3. Fu, K.S., Lee,C.S. G. &Gonzalez, R. (1987) . *Robotics: Control,Sensing, vision and intelligence*. Tata McGraw-Hill Education
4. Mittal, R.K.& Nagrath, I. J.(2018). *Robotics and Control*. Tata McGraw-Hill Education.
5. Craig, J. J. (2008). *Introduction to Robotics: Mechanics and Control* (3rded.). Pearson Education.
6. Spong, M. W. &Vidyasagar, M. (2008). *Robot Dynamics and Control*. John Wiley & Sons.
7. Siciliano , B. & Sciavicco, L. (2010). *Robotics: Modelling, Planning and Control*. Springer.

Suggested E-Learning Material:

1. https://nptel.ac.in/courses/112101099/
2. https://www.edx.org/course/robotics-1
3. https://www.coursera.org/specializations/robotics
4. https://ocw.mit.edu/courses/mechanical-engineering/2-12-introduction-to-robotics-fall-2005/
5. https://www.edx.org/course/robotics-dynamics-control-pennx-robo3x
6. https://onlinecourses.nptel.ac.in/noc18_me61/preview
7. https://swayam.gov.in/courses/4859-july-2018-robotics
8. https://www.edx.org/learn/robotics
   https://www.coursera.org/specializations/robotics

CS 507 Artificial Intelligence

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Section-A

Introduction to Artificial Intelligence, General problem solving, state space and graph model techniques, Heuristic designs, Aim-oriented heuristic algorithms versus solution guaranteed algorithms, Game playing strategies.

Knowledge Representation : Knowledge representation tools, First order predicate calculus. Understanding Logic Programming Using PROLOG. Semantic Nets, Frames, production rules, knowledge base, the inference system, forward and backward deduction.

Section-B

Cognitive Computing: Introduction, Elements of Cognitive Systems. Understanding Complex Relationships Between Systems. Understanding Cognition. Transformation of Artificial Intelligence into Cognitive Computing Systems. Uses of Cognitive Computing Systems. System of Judgment and Choice. Designing a Cognitive System. Graining Insight from Data. Bringing Data into Cognitive System. Defining Objective.

Defining Domain. Understanding the Intended Users and Defining their Attributes. Defining Questions and Exploring Insights. Creating and Refining the Corpora. Training and Testing.Understanding Natural Language, Parsing techniques, context free and transformational grammar, transition net, augmented transition nets, Fillmore's grammar, Shanks conceptual dependency. Grammar free analysers, Sentence generation, Translation.

Section-C

Enabling Reasoning in Cognitive Systems Through Probabilistic Learning: Bayesian Networks, Approximate Inference, Constructing Bayesian Networks. Markov Chains, Hidden Markov Model: Forward Algorithm, Viterbi Algorithm, Baum-Welch Algorithm.Application of Cognitive Computing: Enhancing the Shopping Experience. Leveraging the Connected World of Internet of Things. Voice of the Computer. Fraud Detection. Case Study of Cognitive Computing Systems.

Suggested Books:

1. Russell, S. J., & Norvig, P. (2013). *Artificial Intelligence: A Modern Approach* (3rd ed.). PHI Learning.
2. Vernon, D. (2014). Artificial Cognitive Systems: A Primer. MIT Press.
3. Rich, E., & Knight, K. (2011). *Artificial Intelligence* (3rd ed.). Tata McGraw-Hill.
4. Patterson, D. W. (1990). *Introduction to Artificial Intelligence and Expert Systems*. PHI Learning.
5. Barr, A., Cohen, P. R., & Feigenbaum, E. A. (1982). *The Handbook of Artificial Intelligence*. Addison-Wesley.
6. Allen, J. (1995). *Natural Language Understanding* (2nd ed.). Pearson Education India.
7. Nilsson N.J., (1991). *Principles of Artificial Intelligence*. Narosa Publishing.
8. Nilsson, N. J. (1998). *Artificial intelligence: A New Synthesis*. Morgan Kaufmann Inc.

9. Luger, G. F. (2002). *Artificial intelligence: Structures and Strategies for Complex Problem Solving*. Addison-Wesley.
10. Charniak E., & McDermott D. (1985). *Introduction to Artificial Intelligence*. Addison-Wesley.

Suggested E-Resources:

1. Artificial Intelligence by IIT Kharagpur
   https://nptel.ac.in/courses/106105077/
2. Artificial Intelligence: Principles and Techniques by Stanford University
   https://web.stanford.edu/class/cs221/

CS 511 Cloud Computing

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

On successful completion of the course students will be able to

- Apply cloud computing model in real application.
- Use programming paradigms like MapReduce to create applications.
- Operate cloud by installing virtual machines and apply migration.
- Understand the challenges of cloud
- Aware about the Access Control mechanisms of cloud.

Section-A

Cloud Computing Fundamentals: Definition, Characteristics, Evolution, Architecture, deployment models and service models, Cloud Computing Stack, Applications, Benefits, and Limitation.

Web Technologies for Cloud: Service Oriented Architecture, Web 2.0, Web services, Data Format (XML, JSON).

Virtualization Technology: Overview, Architecture, Virtual machine technology, Virtual Machine Provisioning & Migration, Fault Tolerance Mechanisms. virtualization of data centers.

Section-B

Resource Management and Load Balancing: Distributed Management of Virtual Infrastructures, Server consolidation, Dynamic provisioning and resource management, Resource Optimization, Resource dynamic reconfiguration, Scheduling Techniques for Advance Reservation, Capacity Management to meet SLA Requirements, and Load Balancing, various load balancing techniques.

Interoperability: Issues with interoperability, Federated clouds, Cloud federation stack, Interoperability approaches.

Implementation: Study of Cloud computing Systems like Amazon EC2 and S3, Google App Engine, and Microsoft Azure, Build Private/Hybrid Cloud using open source tools (OpenStack**, Docker).**

Section-C

Data In Cloud: Characterizing data-intensive computations, Technologies for data-intensive computing, Cloud file systems:GFS And HDFS, NoSQL systems: Big Table, HBase, Programming platforms: Map-Reduce.

Cloud Security: Vulnerability Issues and Security Threats, Application-level, Security, Data level Security, and Virtual Machine level Security, Infrastructure Security, and Multi-tenancy Issues.

Advances: Energy efficiency in clouds, Green Computing, Fog Computing, Mobile Cloud Computing, Cloud Standards.

Suggested Books:

1. Krutz, R. L., & Vines, R. D. (2010). *Cloud Security: A Comprehensive Guide to Secure Cloud Computing*. Wiley Publication.
2. Shroff, G. (2010). *Enterprise Cloud Computing: Technology, Architecture, Applications*. Cambridge University Press.
3. Mather, T., Kumaraswamy, S., & Latif, S. (2009). *Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance*. O'Reilly Media, Inc.
4. Velte, A. T., Velte, T. J., Elsenpeter, R. C., & Elsenpeter, R. C. (2010). *Cloud Computing: A Practical Approach*. Tata McGraw-Hill.
5. Saurabh K. (2011). *Cloud Computing* (1st ed.). WILEY India Pvt. Ltd.
6. Sosinsky, B. (2011). *Cloud Computing*. WILEY India Pvt. Ltd.

7. Ferretti, S., Ghini, V., Panzieri, F., Pellegrini, M., & Turrini, E. (2010). *QoS–Aware Clouds*. IEEE 3rd International Conference on Cloud Computing.

Suggested E-Resources:

1. Cloud Computing
   https://nptel.ac.in/courses/106105167/1
2. Cloud Computing Specialization
   https://www.coursera.org/specializations/cloud-computing

READING ELECTIVES

CHE 419R Membrane Separation Technology

Max. Marks : 100	**L**	**T**	**P**	**C**
(ESA: 100)	**0**	**0**	**4**	**2**

Learning Outcomes:

The students will be able to:

- Understand the principles and materials properties for different membrane separation processes
- Identify the best membrane modules and manufacturing process for different applications
- Identify and design the suitable membrane separation technique for intended problem

Section-A

Introduction to membrane separation processes: History, their classification, material & material properties and applications.

General transport theories: driving forces, transport through porous (knudsen flow & friction model) and nonporous membranes.

Module and process design: plate & frame module, spiral wound module, tubular module, Hollow fiber module, comparative study of module configuration.

Section-B

Synthetic Membrane preparation techniques: Phase inversion membranes, preparation of composite membranes, Characterization of porous (Microfiltration, bubble point method, gas adsorption-desorption & permeability method), ionic and nonporous (permeability, physical & density measurement methods) membranes.

Section-C

Design and analysis and industrial application of various membrane processes such as reverse osmosis, ultra-filtration, electro-dialysis, dialysis, liquid membrane separation, gas permeation and pervaporation.

Concentration polarization and membrane fouling: causes of fouling, pressure drop, temperature polarization, gel layer & osmotic pressure model, Methods to reduce fouling.

Recommended Books:

1. Mulder, M. (1996). Basic principles of membrane technology. Second. Kluwer Academic Pub.
2. Baker, R. W. (2012). Membrane technology and applications. John Wiley & Sons.
3. Noble, R. D., & Stern, S. A. (Eds.). (1995). Membrane separations technology: Principles and applications. (Vol. 2). Elsevier.
4. Strathmann, H. (2004). Ion-exchange membrane separation processes. (Vol. 9). Elsevier.

E-resource(s): https://nptel.ac.in

CHE 417R Corrosion Engineering

Max. Marks : 100	**L**	**T**	**P**	**C**
(ESA: 100)	**0**	**0**	**4**	**2**

Learning Outcomes:

The students will be able to:

- Understand the electrochemical and metallurgical behavior of corroding systems.
- Apply the electrochemical and metallurgical aspects of combating eight forms of corrosion.
- Select or choose the testing procedures for corroding systems.
- Evaluate the polarization behavior of corroding systems.
- Design of suitable materials, methods to combat corrosion.
- Predict the function of corrosion inhibitor

Section-A

Corrosion - Definition, classification, forms of corrosion, expressions for corrosion rate, emf and galvanic series, merits and demerits, Electrochemical, Environmental Metallurgical and other aspects. Eight forms of corrosion; Galvanic corrosion, Crevice corrosion, Pitting, Intergranular corrosion, Selective leaching, Erosion corrosion, Stress corrosion and Hydrogen damage; Causes and remedial measures.

Section-B

Purpose of corrosion testing, classification, susceptibility, Surface preparation and areation. Tests for Galvanic corrosion, Inter-granular corrosion, Stress corrosion, Pitting, Crevice and Erosion corrosion. Tests for Stainless steels and metals. NACE test methods. instrumentation.

Corrosion prevention; Materials selection, Alteration of environment, Design, Cathodic and anodic protection and Coatings.

Section-C

Theory of corrosion; Principles and applications. Thermodynamics and electrode kinetics. Activation, concentration and combined polarization. Passivity and mechanism of growth and breakdown of passive films. Predicting corrosion behavior, anodic protection, noble metal alloying. Tafel extrapolation, linear polarization. High-tempreature corrosion; Pilling Bedworth ratio Electrochemical and morphological aspects of sxidation, Oxiation Kinetics, High temperature materials.

Recommended Books:

1. Fontana, M. G. (2005). Corrosion engineering. Tata McGraw-Hill Education.
2. Narayan, R. (1983). An introduction to metallic corrosion and its prevention. Mohan Primlani for Oxford & IBH Publishing Company.
3. Budinski, K. G. (1988). Surface engineering for wear resistance. (Retroactive Coverage). Prentice-Hall, Inc.
4. Uhlig, H.H. (1985). Corrosion and corrosion control. New York: John Wiley and Sons.

E-resource(s): https://nptel.ac.in

CHE 418R Enzyme Engineering

Max. Marks : 100	**L**	**T**	**P**	**C**
(ESA: 100)	**0**	**0**	**4**	**2**

Learning Outcomes:

The students will be able to:

- Recognize the factors affecting enzyme activity and its kinetics
- Understand the role enzyme as a catalyst in chemical industries
- Understand how enzyme kinetics affects reactor design for large scale production

Section-A

Introduction to biochemistry - Function and applications, nature and function of enzyme. coenzyme/ cofactor - Classification of enzymes - Assay methods and units - Applications of enzymes in industry, analytical techniques, medicine and pharmaceuticals Kinetics and mechanism of enzyme catalysis, Enzyme catalysis and controlling factors - Kinetics of enzyme catalyzed reactions in solution - Immobilized enzyme reaction kinetics - Effect of mass transfer resistance

Section-B

Enzyme production on large scale technology, isolation and purification of enzyme, protein, protein fractionalization methods

Immobilization technology and development, immobilization technique for enzymes - Characteristics and uses for immobilized enzyme systems.

Section-C

Industrial bioreactors utilizing isolated enzymes and biosensors development and applications - Reactor design and analysis for immobilized enzyme reactors - Applications in biosensors – Some modern developments for enzyme in organic synthesis.

Recommended Books:

1. Bailey, J. E., & Ollis, D. F. (1986). Biochemical engineering fundamentals. New York: Mcgraw Hill Publishing Company.
2. Wiseman, A. (1985). Handbook of enzyme biotechnology. E. Horwood.
3. Schomburg, D., Stephan, D., & Gesellschaft für Biotechnologische Forschung (Braunschweig, Germany). (1996). Enzyme handbook: 12. Berlin: Springer.
4. Pye, E. K, & Wingard, L. B. (1974). Enzyme engineering: 2. New York: Plenum Press.
5. Palmer, T., & Bonner, P. L. (2007). Enzymes: biochemistry, biotechnology, clinical chemistry. Elsevier.

E-resource(s): https://nptel.ac.in

CHE 420R Renewable Energy Resources

Max. Marks : 100	**L**	**T**	**P**	**C**
(ESA: 100)	**0**	**0**	**4**	**2**

Learning Outcomes:

The students will be able to:

- Recognize the types of renewable energy resources
- Recognize the advantages of renewable energy resources on environment
- Do cost benefit analysis
- Efficiency of renewable energy systems as compared to conventional energy system

Section –A

Energy and Power, conventional energy sources.

Renewable energy sources, solar energy alternatives, optimal tilt for solar equipments.

Solar photovoltaic technologies, solar photovoltaic systems and their comonents.

Wind energy, wind flow, power in the wind, types of wind turbines, wind trubine sizing and systems design.

Section –B

Biomass energy, introduction, types of biomass and their applications, energy content of biomass, biomass as a source of energy, biomass-based fuels, structure of a biogas plant, design of a biogas plant, costing and payback period.

Chemical energy sources, hydrogen energy-technology, production storage transportation alternate fuel for moor vehicles, safety and management.

Section –C

Magneto hydro dynamic power, thermo electric power, thermionic generation, thermonuclear fusion energy, Energy storage and distribution

Energy conservation concept, principles technologies involved. Co-generation, waste heat utilization heat recuperators, regenerators, heat pipes & pumps.

Renewable energy sources and devices and their instrumentation and control

Recommended Books:

1. Rai, G. D. (2013). Non-conventional sources of energy. Khanna Publishers.
2. Singal, R. K. (2009). Non-conventional energy resources. S K Kataria and Sons.
3. Chiogioji, M. H. (1979). Industrial energy conservation. New York: McGraw Hill.
4. Solanki, C. S. (2009). Renewable energy technologies: A practical guide for beginners. PHI Learning Pvt. Ltd.

E-resource(s): https://nptel.ac.in

CHE 416R Computer Aided Process Plant Design

Max. Marks : 100	**L**	**T**	**P**	**C**
(ESA: 100)	**0**	**0**	**4**	**2**

Learning Outcomes:

The students will be able to:

- Create hierarchy of process design
- Develop models for preliminary systems
- Create CAD model for fluid, heat and mass transfer equipment

Section-A

Introduction and properties evaluation - spread sheeting, hierarchy of process design and the onion model - flow sheeting, typical unit of cad system - process synthesis - physical properties evaluation - Transport properties and thermodynamic properties of gases and binary mixtures.

Basic model development for preliminary systems , methods of calculating vapor liquid equilibrium data for ideal and non-ideal mixtures, bubble point and dew point, flash and distillation calculations, equipment design, development of software programs for the following systems, piping system - Single phase and two phases.

Section-B

Fluid Moving Machinery: Cad Model for fluid moving machinery and storage design – Separator system - Two phase and three phase - Storage system - Atmospheric, pressurized cryogenics.

Heat Transfer Equipment: CAD model for heat transfer equipment design - Double Pipe, Shell and tube heat exchanger - PHE - Air cooler - Heat integration of evaporators.

Section-C

Mass Transfer Equipment: Cad Model for mass transfer equipment and safety devices design - Binary mixtures - Pseudo binary, multistage distillation system – Heat integration of distillation columns - Absorber and strippers – Liquid Liquid extractor - Safety devices-pressure safety valve and flare system.

Recommended Books:

1. Bhattacharyya, B.C & Narayanan, C.M., (2012). Computer aided design of chemical process equipment. New Delhi: New Central Book Agency (P) LTD.
2. Smith, R., & Smith, R. (1995). Chemical process design. New York: McGraw-Hill.
3. Husain, A. (1986). Chemical process simulation. New Delhi: Wiley Eastern Limited.
4. Coker, A. K. (1995). FORTRAN programs for chemical process design, Analysis, and Simulation. Gulf Publishing Company.
5. Bhattacharyya, B.C, Narayanan, C.M., (1992). Computer aided design of chemical process equipment. New Delhi: New Central Book Agency (P) Ltd.

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