सीनेट की तेहत्तरवीं बैठक का कार्यवृत्त

MINUTES OF THE 73rd MEETING OF THE SENATE

10 मई 2018
10th MAY 2018

भारतीय प्रौद्योगिकी संस्थान रूड़की
रूड़की – 247 667 (भारत)
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE – 247 667 (INDIA)

भारतीय प्रौद्योगिकी संस्थान रूड़की
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रूड़की 247 667
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सूची/I N D E X

प्रशान्त गुप्ता
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73.7	सत्र 2018–19 के लिए शैक्षणिक कलैन्डर पर विचार करना। To consider the Academic Calendar for the session 2018-19.	4
73.8	एम टेक / पीएचडी कार्यक्रमों में विदेशी छात्रों के प्रवेश के लिए योग्यता मानदंडो पर विचार करना। To consider eligibility criteria for admission of foreign students in M.Tech. / Ph.D. programmes.	4
73.9	भारत में अध्ययन कार्यक्रम के माध्यम से एमटेक/पीएचडी प्रोग्राम में विदेशी छात्रों के प्रवेश सम्बन्धित सीटो की संख्या की पुष्टि करना। To ratify the seats for admission of foreign students in M.Tech. / Ph.D. programmes through Study in India programme.	4
73.10	अनंतिम डिग्री प्रमाण पत्र (पीडीसी) और कन्वोकेशन के दौरान दी जाने वाली डिग्री पर उल्लिखित तिथियों से सम्बन्धित सुझाव पर विचार करना। To consider the suggestion regarding the dates mentioned on Provisional Degree Certificate (PDC) and degree given to Ph.D. students during convocation.	4
73.11	पीएचडी थीसिस शीर्षक के लिए 80 अक्षरों की सीमा बढ़ाने पर विचार करना। To consider increasing the limit of 80 characters for Ph.D. thesis title.	4
73.12	डिग्री प्रमाण पत्र और हस्ताक्षर के तरीके पर हस्ताक्षरकर्ताओं की संख्या और अनुक्रम पर विचार करना। To consider the number and sequence of signatories on degree certificate and the mode of signature.	4
73.13	उन छात्रों को अनंतिम पी0एच0डी0 उपाधि प्रदान करने की पुष्टि किया जाना, जिन्होंने विभिन्न पाठ्यक्रमों में 28 दिसम्बर 2017 से अब तक उपाधि प्राप्त किए जाने की अर्हता प्राप्त की है। To ratify the award of provisional Ph.D. Degrees certificate to the students who have completed the requirements for the award of Ph.D. Degree in various disciplines w.e.f. 28th December 2017 to date.	5
73.14	सत्र 2018-19 से पीडी - पीजी छात्रों (पीएचडी और एमबीए सहित) के लिए पूर्ण ट्यूशन फीस छूट के लिए अनुमोदन की स्वीकृति की पुष्टि करना। To ratify the approval towards full Tuition Fee Waiver for PD-PG students (including Ph.D. & MBA) from the session 2018-19.	5

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प्रशान्त गर्ग

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
MEETING SECTION

Minutes of the 73rd Meeting of the Senate held on 10.05.2018 at 4.00 P.M. in the Senate Hall of the Institute.

Following were present:

1.	Prof. Ajit K. Chaturvedi	Director & Chairman
2.	Prof. Pushplata	(Architecture & Planning)
3.	Prof. Ila Gupta	(Architecture & Planning)
4.	Prof. R.P. Singh	(Biotechnology)
5.	Prof. Ramasare Prasad	(Biotechnology)
6.	Prof. Partha Roy	(Biotechnology)
7.	Prof. Shishir Sinha	(Chemical Engineering)
8.	Prof. Mala Nath	(Chemistry)
9.	Prof. U.P. Singh	(Chemistry)
10.	Prof. M.R. Maurya	(Chemistry)
11.	Prof. Bina Gupta	(Chemistry)
12.	Prof. S.S. Jain	(Civil Engineering)
13.	Prof. P.K. Garg	(Civil Engineering)
14.	Prof. C.S.P. Ojha	(Civil Engineering)
15.	Prof. Pradeep Bhargava	(Civil Engineering)
16.	Prof. Mahendra Singh	(Civil Engineering)
17.	Prof. Praveen Kumar	(Civil Engineering)
18.	Prof. N.K. Samadhiya	(Civil Engineering)
19.	Prof. Akhil Upadhyay	(Civil Engineering)
20.	Prof. Kamal Jain	(Civil Engineering)
21.	Prof. B.R. Gurjar	(Civil Engineering)
22.	Prof. M.L. Sharma	(Earthquake Engineering)
23.	Prof. B.K. Maheshwari	(Earthquake Engineering)
24.	Prof. Sunil Bajpai	(Earth Sciences)
25.	Prof. A.K. Sen	(Earth Sciences)
26.	Prof. Anand Joshi	(Earth Sciences)
27.	Prof. R. Krishnamurthi	(Earth Sciences)
28.	Prof. Rajendra Prasad	(Electrical Engineering)
29.	Prof. N.P. Padhy	(Electrical Engineering)
30.	Prof. Biswarup Das	(Electrical Engineering)
31.	Prof. M.J Nigam	(Electronics & Communication Engg.)
32.	Prof. M.V. Kartikeyan	(Electronics & Communication Engg.)
33.	Prof. Debashish Ghosh	(Electronics & Communication Engg.)
34.	Prof. M. Perumal	(Hydrology)
35.	Prof. Nagendra Kumar	(Humanities & Social Sciences)

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36. Prof. Y.S. Negi (Paper Technology)
37. Prof. S.C. Sharma (Paper Technology)
38. Prof. Sunita Gakkhar (Mathematics)
39. Prof. Kusum Deep (Mathematics)
40. Prof. Tanuja Srivastava (Mathematics)
41. Prof. N. Sukavanam (Mathematics)
42. Prof. S.C. Sharma (Mechanical & Industrial Engg.)
43. Prof. P.K. Jain (Mechanical & Industrial Engg.)
44. Prof. Dinesh Kumar (Mechanical & Industrial Engg.)
45. Prof. Akhilesh Gupta (Mechanical & Industrial Engg.)
46. Prof. B.K. Gandhi (Mechanical & Industrial Engg.)
47. Prof. B.K. Mishra (Mechanical & Industrial Engg.)
48. Prof. S.K. Nath (Metallurgical & Materials Engg.)
49. Prof. Anjan Sil (Metallurgical & Materials Engg.)
50. Prof. B.S.S. Daniel (Metallurgical & Materials Engg.)
51. Prof. Rajesh Srivastava (Physics)
52. Prof. Tashi Nautiyal (Physics)
53. Prof. K.L. Yadav (Physics)
54. Prof. G.D. Varma (Physics)
55. Prof. M.L. Kansal (WRD&M)
56. Prof. Deepak Khare (WRD&M)
57. Prof. S.K. Mishra (WRD&M)
58. Prof. R.P. Saini (Alternate Hydro Energy Centre)
59. Prof. M.P. Sharma (Alternate Hydro Energy Centre)
60. Prof. R. Balasubramanian, Head, Institute Computer Centre
61. Prof. S.K. Singhal, Head, Alternate Hydro Energy Centre
62. Prof. A.K. Sharma, Head, Department of Biotechnology
63. Prof. M.K. Jain, Head, Department of Hydrology
64. Prof. R.K. Dutta, Head, Centre of Nanotechnology
65. Prof. Mahua Mukherjee, Head, CoEDM&M
66. Prof. P. Gopinath, ADOAA (Admission)
67. Prof. Vipul Rastogi, ADOAA (Curriculum)
68. Prof. Rajat Rastogi, ADOAA (Evaluation)
69. Prof. S.H. Upadhyay, Asso. Dean of Students' Welfare (Bhawans & Mess)
70. Prof. Pravindra Kumar, Associate Dean, Corporate Interaction (ADCI)
71. Prof. M.K. Barua, Associate Dean of Students' Welfare (Students Activities)
72. Prof. P. Arumugam, Associate Dean (International Relations)

Students' representatives:

73. Mr. Manik Verma, General Secretary, Students' Affairs Council
74. Mr. Rajesh Kumar Vishwakarma, General Secretary Academic Affairs (PG)

75. Mr. Prashant Garg
Registrar & Secretary, Senate

At the outset, the Chairman welcomed the members to the 73rd meeting of the Senate.

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The Chairman thanked and placed on record the valuable contributions of Prof. Ravi Bhushan, Department of Chemistry, outgoing Senate member in the meetings of the Senate.

The Senate noted the communications received from the following members for their inability to attend the current meeting:

1. Dr. Sharad K. Jain, Director, NIH, Roorkee
2. Prof. Ramesh Chandra, Institute Instrumentation Centre
3. Prof. Rama Bhargava, Department of Mathematics
4. Prof. Davinder Kaul Walia, Department of Physics
5. Prof. Manish Shrikhande, Department of Earthquake Engineering
6. Prof. S.K. Ghosh, Department of Civil Engineering
7. Dr. C. Jayakumar, Librarian

The Agenda was then taken up:

Item No. 73.1: To confirm the minutes of the 72nd meeting of the Senate held on 22.03.2018.

The minutes of the 72nd meeting of the Senate held on 22.03.2018 and circulated vide e-mail dated 17.04.2018 were confirmed.

Item No. 73.2: To report the actions taken to implement the decisions of the Senate taken in its 72nd meeting held on 22.03.2018.

The Senate noted the actions taken on the said minutes.

Item No.73.3: To consider the mechanism for considering appeals related to academic affairs.

The Senate approved the proposal.

Item No. 73.4: To consider the revised guidelines for casual students.

The Senate approved the proposal.

Item No. 73.5: To consider the proposal to discontinue the practice of admitting interns through academic affairs office.

The Senate approved the proposal with effect from the next academic year.

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Item No. 73.6: **To consider the syllabi of courses of M. Tech. (Chemical Engineering).**

The Senate approved the item as given in **Appendix 'A'**.

Item No. 73.7: **To consider the Academic Calendar for the session 2018-19.**

The Senate approved the item as given in **Appendix 'B'**.

Item No. 73.8: **To consider eligibility criteria for admission of foreign students in M.Tech./Ph.D. programmes.**

The Senate approved the proposal.

Item No. 73.9: **To ratify the seats for admission of foreign students in M.Tech./Ph.D. programmes through Study in India programme.**

The Senate ratified the item.

Item No. 73.10: **To consider the suggestion regarding the dates mentioned on Provisional Degree Certificate (PDC) and degree given to Ph.D. students during convocation.**

The Senate considered the proposal and approved that only the date of viva-voce be printed on Provisional Degree Certificate and the date of Convocation be printed on the Degree Certificate as given in **Appendix 'C'**.

Item No. 73.11: **To consider increasing the limit of 80 characters for Ph.D. thesis title.**

The Senate considered the proposal and approved the same without any limit on the number of characters in Ph.D. thesis title.

Item No. 73.12: **To consider the number and sequence of signatories on degree certificate and the mode of signature.**

The Senate considered the proposal and approved that the degree will have only two ink signatures - Registrar on the left and the Chairman, Senate & Director on the right. Further, suggested that the degree be examined from the design perspective with a view to improve its aesthetics.

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Item No. 73.13: To ratify the award of provisional Ph.D. Degree certificates to the students who have completed the requirements for the award of Ph.D. Degree in various disciplines w.e.f. 28th December 2017 to date.

The Senate ratified the item as given in **Appendix 'D'.**

Item No. 73.14: To ratify the approval towards full Tuition Fee Waiver for PD-PG students (including Ph.D. & MBA) from the session 2018-19.

The Senate ratified the item.

The meeting ended with a vote of thanks to the Chair.

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE- 501** Course Title: **Mathematical Methods in Chemical Engineering**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge of advanced numerical methods and their applications to chemical engineering problems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Vectors and tensors: Vectors, vector spaces, metric, norm and inner product, linear dependence, Gram-Schmidt ortho-normalization, introduction to tensor, tensor algebra and calculus.	6
2.	Matrix algebra, determinants and properties, Adjoint, self-adjoint operators, Eigenvalue and eigenvectors, solvability conditions, solution of set of algebraic equations, solution of set of ordinary differential equations, solution of set of non-homogeneous first order ordinary differential equations, non-self adjoint systems, stability analysis, bifurcation theory	9
3.	Partial differential equations: classification, boundary conditions, linear superposition	3
4.	Second order linear ODEs, Sturm Liouville Operators, Spectral expansion, Special functions. Inverse of second order operators and Green's function	7
5.	Second order linear partial differential equations (PDEs): Classification, canonical forms. Solution methods for hyperbolic, elliptic and parabolic equations: Eigen function expansion, separation of variables, transform methods. Applications from heat and mass transfer, reaction engineering.	8
6.	Numerical solution of linear and nonlinear algebraic equations, Gauss elimination methods, LU decomposition, Newton-Raphson method; Finite difference method for solving ODEs and PDEs. Spectral methods for solving differential equations, Chemical engineering applications from	9

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	separation processes, reaction engineering, fluid mechanics etc..	
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Schneider,H., Barker, G.P.*Matrices and Linear Algebra,* Dover, NY	1972
2.	Gerald C. F. and Wheatly P. O.; "Applied Numerical Analysis", 7th Ed., Addison Wesley.	2003
3.	Ray, A. K., Gupta, S. K. *Mathematical Methods in Chemical and Environmental Engineering,* International Thomson Learning,Singapore	2004
4.	Pushpavanam, S. *Mathematical Methods in Chemical Engineering,* Prentice-Hall of India, New Delhi	2004
5.	Chapra, S. C., Canale, R. P. *Numerical Methods for Engineers,* Tata McGraw-Hill, New Delhi	2006

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE- 503** Course Title: **Advanced Transport Phenomena**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To provide advanced concepts of momentum, mass and heat transfer operations.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Review of basic principles and equations of change in transport of momentum, heat and mass; Viscosity, thermal conductivity and diffusivity; Shell balance for simple situations to obtain shear stress, velocity, heat flux, temperature, mass flux and concentration distributions.	8
2.	**Equations of Change**: Equations of continuity, motion, mechanical energy, angular momentum, energy, and equation of continuity for multicomponent mixture. Use of the equations of change in solving problems of momentum, heat and mass transport, dimensional analysis of the equation of change.	8
3.	**Distributions with More than One Independent Variable**: Unsteady state flow, heat and mass transfer problems, creeping flow around a sphere, flow through a rectangular channel, unsteady heat conduction in slabs with and without changing heat flux, heat conduction in laminar in compressible flow, potential flow of heat in solids, unsteady state diffusive mass transport, steady state transport of mass in binary boundary layers.	8
4.	**Transport of Mass, Momentum and Heat under Turbulent Flow Conditions**: Velocity, temperature and concentration distributions in smooth cylindrical tubes for incompressible fluids, empirical equations for various transport fluxes and momentum.	6
5.	**Interphase Transport in Isothermal and Non-Isothermal Mixtures**: Definitions of friction factor and heat and mass transfer coefficients; Heat and mass transfer in fluids flowing through closed conduits and packed beds; Mass transfer	6

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	accompanied with chemical reaction in packed beds; Combined heat and mass transfer by free and forced convection; Transfer coefficients at high net mass transfer rate.	
6.	**Macroscopic Balances:** Momentum, heat and mass balances and their application, use of macroscopic balances in steady and unsteady state problems; Cooling and heating of a liquid in stirred tank, start-up of a chemical reactor.	6
Total		**42**

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Bird R.B., Stewart W.E. and Lightfoot E.N., "Transport Phenomena", 2nd Ed., Wiley.	1994
2.	Leal L.G., "Advanced *Transport Phenomena*: Fluid Mechanics and Convective Transport Processes", Cambridge University Press.	2007
3.	Dean W.M., "Analysis of Transport Phenomena", 2nd Ed, Oxford University Press.	2012
4.	Brodkey R.S. and Hershey H.C., "Transport Phenomena – A Unified Approach", Brodkey.	2003

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-505** Course Title: **Advanced Reaction Engineering**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge of advanced chemical reactors design and heterogeneous catalysis.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of design of ideal isothermal homogeneous reactors for single and multiple reactions Adiabatic and non-adiabatic operations in batch and flow reactors, optimal temperature progression, hot spot in tubular reactor, autothermal operation and steady state multiplicity in continuously stirred tank reactor(CSTR), and tubular reactors, introduction to bifurcation theory.	8
2.	Rate equations for fluid solid catalytic reactions: Rates of adsorption, desorption, surface reactions in terms of fluid phase concentration at the catalyst surface, qualitative analysis of rate equations, quantitative interpretation of kinetics data	4
3.	Diffusion and reaction: External diffusion effects on heterogeneous reaction, diffusion and reaction in spherical pellets, internal effectiveness factor, falsified kinetics, overall effectiveness factor, estimation of diffusion and reaction limited regimes, Wisz-Prater criterion for internal diffusion, Mears criterion for external diffusion, inter pellet heat and mass transfer, mass and heat transfer with reaction in a packed bed Multiphase reactors: Gas-liquid-solid reactors, hydrodynamics and design of bubble column, slurry reactors, trickle bed reactors.	8
4.	Residence time distribution (RTD) of ideal reactors, interpretation of RTD data, flow models for non-ideal reactors-Axial dispersion, N-tanks in series, and	8

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	multiparameter models, diagnosing the ills of reactors, influence of RTD and micromixing on conversion.	
5.	Solid catalysis: Introduction, Definitions, catalytic properties, classification of catalysts, steps in catalytic reaction, adsorption isotherm, chemisorptions, synthesizing rate law, mechanism and rate limiting steps, deducing a rate law from the experimental data, finding a mechanism consistent with experimental observation, evaluation of rate law parameters	**6**
6.	Catalyst synthesis, impregnation, sol-gel, catalyst characterization by BET, H2-TPR,TPD,Chemisorption, XRD, UV-vis-NIR, TGA/DTG, Fe-SEM, TEM, FTIR, Raman, XPS etc., Catalyst promoters and inhibitors, catalyst poisoning, types of catalyst deactivation, kinetics of catalytic deactivation, temperature-time trajectories, moving bed reactor, straight through transport reactors,	**8**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	Fogler H.S., "Elements of Chemical Reaction Engineering",4th Ed., Prentice Hall of India	2014
2.	Levenspiel O., " Chemical Reaction Engineering", 3rd Ed., Wiley-India	2008
3.	Kulkarni Sulabha K., "Nanotechnology Principles and Practices", 3rd Ed., Capital Publishing Company, New Delhi	2016
4.	Banwell Colin N., and McCash Elaine M., " Fundamentals of Molecular Spectroscopy", 5th Ed., McGraw Hill Education (India) Pvt. Ltd, New Delhi	2013

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-507** Course Title: **Advanced Thermodynamics and Molecular Simulations**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of advanced thermodynamic concepts and molecular simulation methods. The main emphasis will be on the underlying physics and algorithms; programming and the use of software packages will be briefly described.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Probability, Distributions, and Thermodynamic Equilibrium. Laws of Thermodynamics, Partition Function, Thermodynamic Functions and Thermodynamic Ensembles, Maxwell Relations, Phase Space, Averages and Fluctuations, Boltzmann Approximation, Review of Relevant Mathematical and Programming Concepts	**12**
2.	Gibbs Phase Rule and Phase Equilibrium, Equations of State, Solution Thermodynamics, Phase equilibrium, Osmotic Pressure, Chemical Potential, Mixing and Phase Separation, Theory of electrolytes	**8**
2.	Monte Carlo Simulations: Setting up a Simulation, Types of Boundary conditions, Detailed Balance, Numerical Implementation, Analysis and Interpretation of Results, Advanced Sampling Strategies	**8**
3.	Molecular Dynamics Simulations in Various Ensembles: Numerical Integration of Equations of Motion, Temperature and Pressure Control, Force-Fields, Analysis and Interpretation of Results, Efficiency and Parallelization	**6**
4.	Methods for Free Energy Calculations: Thermodynamic Integration, Widom's Particle Insertion Method, Umbrella Sampling, and Other	**4**

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	Advanced Strategies	
5.	Non-equilibrium Simulations: Langevin Equations, Brownian Dynamics, Kinetic Monte Carlo (kMC) Simulations, and Other Methods	**4**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1	Mcquarrie, D.A. Statistical Mechanics, Univ Science Books; 1st edition	2000
2	Hanson, R.M. and Green, S. Introduction to Molecular Thermodynamics, University Science Books	2008
3	Shell, M.S. Thermodynamics and Statistical Mechanics. Cambridge University Press	2015
4	Frenkel, Daan, and Berend Smit. Understanding molecular simulation: from algorithms to applications. Vol. 1. Academic press.	2001
5	Tildesley, D. J., and M. P. Allen. "Computer simulation of liquids." Clarendon, Oxford,	1987
6	Andrew R. Leach. Molecular modelling: principles and applications. Pearson Education.	2001

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-511** Course Title: **Process Integration**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Autumn** 7.Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce concept of process integration in chemical and allied industries.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Process integration (PI) and its building blocks, available techniques for implementation of PI, application of PI.	6
2.	**Pinch Technology:** Basic concepts, role of thermodynamics. Data extraction, targeting, designing, optimization-supertargeting. Grid diagram, composite curve, problem table algorithm, grand composite curve.	9
3.	**Targeting of Heat Exchanger Network (HEN):** Energy targeting, area targeting, number of units targeting, shell targeting, cost targeting.	6
4.	**Design of HEN:** Pinch design methods, heuristic rules, stream splitting, design for maximum energy recovery (MER), multiple utilities and pinches, threshold problem, loops and paths, non-MER design, remaining problem analysis, driving force plot.	9
5.	**Heat Integration of Equipment:** Heat engine, heat pump, distillation column, reactor, evaporator, drier, refrigeration system.	9
6.	**Heat and Power Integration:** Co-generation, steam turbine, gas turbine.	3
	Total	42

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11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Kemp I.C., "Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy", 2nd Ed., Butterworth-Heinemann.	2007
2.	Smith R., "Chemical Process Design and Integration", 2nd Ed., Wiley.	2005
3.	Shenoy U.V., "Heat Exchanger Network Synthesis", Gulf Publishing.	1995
4.	Edited by Klemes J., "Handbook of Process Integration (PI): Minimisation of Energy and Water Use, Waste and Emissions", 1st Ed., Woodhead Publishing.	2013

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-513** Course Title: **Biochemical Engineering**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide comprehensive knowledge of biochemical engineering principles and their application.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Biochemical engineering fundamentals, role of biochemical engineering in the biochemical product synthesis, bioprocess economics.	2
2.	**Microbiology:** Cell theory, structure of microbial cells, classification of microorganisms, RDNA technology, genetically engineered microbes (GEMS).	5
3.	**Biochemistry:** Chemical composition of microbial cells; properties, classification and metabolism of lipids, proteins, carbohydrates and enzymes, metabolic stoichiometry and energetics.	5
4.	**Kinetics of Enzyme Catalysed Reactions:** Simple enzyme kinetics with mono and multi substrates, determination of elementary step rate constant; Modulation and regulation of enzyme activity, factors influencing enzyme activity, immobilization of enzymes.	5
5.	**Microbial Fermentation Kinetics:** Bacterial growth cycle, mathematical modeling of batch and continuous fermentations with and without recycles, bioreactors in series, product synthesis kinetics, over all kinetics, thermal death kinetics of spores and cells, transient growth kinetics, deviation from Monod model, comparison between batch and continuous fermentation	8
6.	**Sterilization:** Sterilization and pasteurization, batch and continuous sterilization of media, plate and direct injection sterilization; Thermal death kinetics of spores, cells and viruses.	4
7.	**Aeration and Agitation**: Gas-liquid mass transfer, oxygenation of fermentation broth; bubble and mechanical aeration and agitation, design and power requirement of gassed and un-gassed systems for various impellers, hold-up.	3
8.	**Scale-up of Bioreactors:** Dimensionless numbers for scale-up, design	4

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	estimation of various scale-up parameters, power estimation for gassed and ungassed systems.	
9.	**Aerobic and Anaerobic Fermentations:** Design and analysis of typical aerobic and anaerobic fermentation processes, manufacture of antibiotics, alcohol and other fermentation products.	**3**
10.	**Downstream Processing:** Use of filtration, centrifugation, adsorption, membrane separation processes, electrophoresis chromatography.	**3**
	Total	**42**

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Bailey J.E. and Olis D.F., "Biochemical Engineering Fundamentals", 2nd Ed., McGraw-Hill.	1987
2.	Doble M. and Gummadi S.N., "Biochemical Engineering", Prentice Hall.	2007
3.	Schuler M.L. and Kargi F., "Bioprocess Engineering", 2nd Ed., Prentice Hall.	2002

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-515** Course Title: **Computational Fluid Dynamics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide an understanding of physical models to study hydrodynamics in engineering systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Basic Concepts of Fluid Flow:** Philosophy of computational fluid dynamics (CFD), review of equations of change for transfer processes, simplified flow models such as incompressible, inviscid, potential and creeping flow, flow classification.	5
2.	**Grid Generation:** Structured and unstructured grids, choice of suitable grid, grid transformation of equations, some modern developments in grid generation for solving engineering problems.	3
3.	**Finite Difference Method (FDM):** Discretization of ODE and PDE, approximation for first, second and mixed derivatives, implementation of boundary conditions, discretization errors, applications to engineering problems.	9
4.	**Finite Volume Method (FVM):** Discretization methods, approximations of surface integrals and volume integrals, interpolation and differential practices, implementation of boundary conditions, application to engineering problems.	11
5.	**Special Topics:** Case studies using FDM and FVM, flow and heat transfer in pipes and channels, square cavity flows, reactive flow, multiphase flow, rotary kiln reactors, packed and fluidized bed reactors, furnaces and fire systems. Overview of finite element method (FEM).	14
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Fletcher C.A.J., "Computational Techniques for Fluid Dynamics, Vol. 1:	1998

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	Fundamental and General Techniques", Springer-Verlag.	
2.	Fletcher C.A.J., "Computational Techniques for Fluid Dynamics, Vol. 2: Specific Techniques for Different Flow Categories", Springer-Verlag.	1998
3.	Anderson J.D., "Computational Fluid Dynamics", McGraw Hill.	1995
4.	Ghoshdastidar P.S., "Computer Simulation of Flow and Heat Transfer", Cengage.	2017
5.	Ferziger J.H. and Peric M., "Computational Methods for Fluid Dynamics", 3rd Ed., Springer.	2002
6.	Patankar S.V., "Numerical Heat Transfer and Fluid Flow", Taylor and Francis.	2004

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-517** Course Title: **Optimization of Chemical Processes**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PEC**

8. Pre-requisite: Nil

9. Objective: To introduce various techniques of optimization and their application to chemical processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Optimization and calculus based classical optimization techniques.	5
2.	**One Dimensional Minimization Methods:** Elimination methods- equally spaced points method, Fibonacci method and golden section method; Interpolation methods- quadratic interpolation and cubic interpolation, Newton and quasi-Newton methods.	6
3.	**Linear Programming:** Graphical representation, simplex and revised simplex methods, duality and transportation problems.	7
4.	**Multivariable Non-Linear Programming**: Unconstrained- univariate method, Powell's method, simplex method, rotating coordinate method, steepest descent method, Fletcher Reeves method, Newton's method, Marquardt's method and variable metric (DFP and BFGS) methods; Constrained- complex method, feasible directions method, GRG method, penalty function methods and augmented Lagrange multiplier method.	9
5.	**Dynamic Programming:** Multistage processes- acyclic and cyclic, sub-optimization, principle of optimality and applications.	4
6.	**Geometric Programming (GP)**: Differential calculus and Arithmetic-Geometric inequality approach to unconstrained GP; Constrained GP minimization; GP with mixed inequality constraints and Complementary GP.	6
7.	**Emerging Optimization Techniques**: Genetic algorithm, simulated annealing, particle swarm and ant colony optimization.	5
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of

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		Publication
1.	Edgar T.F., Himmelblau D.M. and Lasdon L.S., "Optimization of Chemical Processes", 2nd Ed., McGraw Hill.	2001
2.	Beveridge G.S.G. and Schechter R.S., "Optimization: Theory and Practice", McGraw Hill.	1970
3.	Rao S.S., "Engineering Optimization Theory and Practice", 4th Ed., Wiley.	2009

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Chemical Engineering**

1. Subject Code: **CHE-510** Course Title: **Advanced Process Control**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide the advanced knowledge of process control.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Feed Back Control:** Review of open loop and closed dynamics, stability using root-locus, and frequency response method, time-integral performance criteria of controllers and tuning methods.	7
2.	**Advanced Control Systems:** Control of systems with inverse response, dead time compensator, cascade control, selective control, split-range control, feed forward and ratio control, internal model, adaptive and inferential control.	11
3.	**Multivariable Control Systems:** Alternative control configurations, interaction and decoupling of loops, relative gain-array method, control for complete plants	7
4.	**State Space Methods:** State variables, description of physical systems, transition and transfer function matrices, use in multivariable control for interacting systems.	5
5.	**Digital Control Systems:** Review of Z transform, elements of digital control loop, sampling and reconstruction of signals, conversion of continuous to discrete-time models, discrete time response and stability, design of controllers, control algorithms.	12
	Total	42

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11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Coughanowr D.R. and LeBlanc S. "Process System Analysis and Control", 3rd Ed., McGraw Hill.	2008
2.	Stephanopoulos G. "Chemical Process Control – An Introduction to Theory and Practice", Prentice-Hall of India.	1990
3.	Seborg D.E., Edgar T. F. and Mellichamp D. A., "Process Dynamics Control", 2nd Ed., John Wiley	2004
4.	Bequette B. W., "Process Control: Modeling, Design and Simulation", Prentice Hall of India	2003
5.	Ogunnaike B. A. and Ray W. H., "Process Dynamics Modeling and Control", Oxford University Press	1994

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-512** Course Title: **Solid and Hazardous Waste Management**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide comprehensive knowledge of treatment, utilization and management of industrial, municipal and hazardous solid wastes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Characterization:** Characterization of industrial and municipal solid wastes - hazardous and non-hazardous wastes. Overview of hazardous waste, battery waste, electronic waste, etc. Solid waste disposal and management – standards, laws and guidelines. Hazardous waste regulations, national and international codes; Authorisation procedure and generator requirement.	6
2.	**Solid Waste Collection, Handling and Transportation:** Generation, collection, handling, separation, storage, transfer and processing of solid waste, recycling of solid waste; Segregation of hazardous and non-hazardous wastes. Identification and characterisation of various kinds of hazardous wastes, introduction to toxicology, evaluation of health risks associated with exposure to hazardous wastes.	10
3.	**Solid and Hazardous Wastes Processing:** Physico-chemical method, biological methods, thermal methods; Recycling and reprocessing, handling and processing of sludge; Utilization of municipal solid wastes for landfill, biogasification and manure production; Recent technological advances in composting and thermal gasification. Processing of and value-winning from electronic wastes, battery wastes, ferrous and non-ferrous wastes, heavy metal containing spent catalysts, spent caustic and tannery wastes.	12
4.	**Landfill**: Site selection and design criteria; Closure, restoration and rehabilitation of landfills. Remediation of hazardous waste landfill; Common treatment facility concept for hazardous wastes.	6

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5.	**Case Studies:** Solid and hazardous waste management in sugar, distillery, pulp and paper, fertilizer, petroleum and petrochemical industries; Management of spent catalysts. Mercury emission and control in thermal power plants and cement plants.	**8**
	Total	**42**

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Tchobanglais G., Theisen H. and Vigil S.A., "Integrated Solid Waste Management: Engineering Principles and Management Issues", McGraw Hill.	1993
2.	Pichtel J., "Waste Management Practices: Municipal, Hazardous and Industrial", CRC Press.	2005
3.	Shah K.L., "Basics of Solid and Hazardous Waste Management Techniques", Prentice Hall.	1999
4.	Tedder D.W. and Pohland F.G. (editors), "Emerging Technologies in Hazardous Waste Management", American Chemical Society.	1990
5.	Conway R.A. and Ross R.D., "Handbook of Industrial Waste Disposal", Van-Nostrand Reinhold.	1980
6.	Side G.W., "Hazardous Materials and Hazardous Waste Management", Wiley.	1993

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-514** Course Title: **Pollution Control Systems**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide comprehensive knowledge of basics and design of pollution control systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Preventive and end-of-pipe (EOP) design; Characterization and monitoring of air pollutants, industrial and municipal waste water; Basic philosophy and selection of air and water pollution control systems; Design criteria: hydraulic loading rate, organic loading rate, residence time, dilution rate; concepts of reduce, recycle and reuse (3R) for economic design.	8
2.	**Air Pollution Control System Design**: Particle size distribution and analysis; Design of air pollution abatement systems, hoods, ducts and fans; Design of stacks with single and multiple entries and drought balance; Effect of moisture, vapour, particulates and gaseous pollutants on the integrity of stacks; Design for maximum effects for dispersion; Design for particulate and gaseous pollutants abatement systems including settling chambers, cyclones, fabric filters, electrostatic precipitators, particulate scrubbers, absorption and adsorption system; Design of multiple equipment in series and their cost optimization.	12
3.	**Wastewater Treatment Plant Design**: Physico-chemical treatment of water including sedimentation, coagulation, flocculation, thickening, floatation. Design, operation, maintenance and control of aerobic (such as aerated lagoon, activated sludge systems, trickling filter and sequential batch reactor) and anaerobic (such as UASB reactors and bio-towers) treatment systems for the treatment of domestic and municipal sewage, and industrial wastes.	12
4.	**Advanced Treatment Processes**: Tertiary treatment systems such as adsorption and ion-exchange; Membrane processes- reverse osmosis, ultrafiltration, nanofiltration and electrodialysis; Advance oxidation systems like wet air oxidation; photo-oxidation; Fenton oxidation, ozone oxidation, etc.; Electrochemical treatment including electrocoagulation and electro-oxidation.	6

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5.	**Solid-waste Disposal**: Physico-chemical method, biological methods, thermal methods; Design of sludge drying beds, thermal and biological processes for sludge and land fillings; Landfill site selection, leachate and gas generation; Design of landfill elements, landfill operation and monitoring.	4
	Total	42

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Henze M., van-Loosdrecht M.C.M., Ekama G.A. and Brdjanovic D., "Biological Wastewater Treatment. Principles, Modelling and Design", IWA publishing.	2008
2.	Tchobanoglous G., Burton F.L., Stensel H.D., "Metcalf and Eddy Inc.- Waste Water Engineering Treatment and Reuse", Tata McGraw-Hill.	2003
3.	Bagchi A., "Design, Construction, and Monitoring of Sanitary Landfill", Wiley.	1990
4.	Theodore L. And Buonicore A.J., "Industrial Air Pollution Control Equipment for Particulates", CRC Press.	1976
5.	Parsons S. "Advanced Oxidation Processes for Water and Wastewater Treatment" IWA Publishing.	2004
6.	Arceivala S.J. and Asolekar S.R., "Wastewater Treatment for Pollution Control and Reuse", 3rd Ed., Tata McGraw Hill.	2007

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-516** Course Title: **Kinetics of Polymerization**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide comprehensive knowledge of basics and design of pollution control systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** polymer, monomer, average chain length and molecular weight of polymers	2
2.	**Classification of polymers:** classification based on (i) origin (natural, synthetic and semi-synthetic) (ii) application and physical properties (resin, plastic, rubber, fiber) (iii) Thermal response (Thermoplastics and thermosetting), (iv) line structure (branched, crosslinked and linear polymer), (v)Tacticity (atactic, synditactic and isotactic) (vi) polarity (polar and non-polar) and (vii) crystallinity (amorphous, crystalline and semi-crystalline), (viii) Polymerization processes (addition and condensation polymerization).	4
3.	**Addition polymerization:** free radical, anioic and cationic polymerization. overall scheme, rate expression for cationic and anionic polymerization **Kinetics and mechanism of free radical polymerization:** overall scheme, rate expression for radical polymerization; integrated rate of polymerization expression; methods of initiation: thermal decomposition, redox initiation, photochemical initiation; dead-end polymerization; chain length and degree of polymerization, kinetic chain length, chain transfer, deviation from ideal kinetics, autoacceleration, polymerization-depolyerization equilibrium.	10
4.	**Techniques of polymerization:** bulk, solution, suspension and emulsion polymerization; kinetics of emulsion polymerization.	6
5.	**Kinetics of Copolymerization by radical chain polymerization**: binary copolymer equation, types of copolymers, integrated binary copolymer equation.	6
6.	**Kinetics of ionic polymerization:** anionic, cationic and coordination polymerization.	4
7.	**Kinetics of condensation polymerization:** reactivity of functional groups, average functionality, Rate expression for condensation polymerization- catalyzed and non-	10

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	catalyzed; equilibrium considerations- closed and open drive system; control of molecular weight, branching and crosslinking.	
	Total	**42**

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Ghosh, Premamoy, "Polymer Science and Technology: Plastics, Rubber, Blends and Composites", Tata McGraw Hill, 3rd Ed.	2017
2	Chanda, Manas, "Advanced Polymer Chemistry: A Problem Solving Guide", Marcel Dekker, 1st Ed	2000
3	Carraher, C.E., "Polymer Chemistry", CRC Press, 10th Ed.	2017
4	Gowarikar, V.R., Vishwanathan, N.V., Sreedhar, J. "Polymer Science", New Age international,	1986

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-518** Course Title: **Waste to Energy Conversion**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To deal with the various types of wastes available and technological options of their exploitation for obtaining useful energy.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**Introduction**: Introduction to energy from waste, characterization and classification of wastes, availability of agro based, forest, industrial, municipal solid waste in India vis-a-vis world, proximate & ultimate analyses, heating value determination of solid liquid and gaseous fuels.	4
2.	**Waste to energy through thermal routes:** Incineration, pyrolysis and gasification of various types of solid wastes. Process fundamentals, reactors, co-processing of various types of wastes, downstream applications of products, hydrogen production, storage and utilization, gas cleanup. Oil from waste plastics.	9
3.	**Waste to energy through biochemical routes:** Municipal and industrial wastewater and their energy potential, anaerobic reactor configuration for fuel gas production from wastewater and sludge. Separation of methane and compression. Concept of microbial fuel cells, gas generation and collection in landfills, bio-hydrogen production through fermentation, composting of solid wastes.	8
4.	**Waste to energy through chemical routes:** Production of bio diesel from discarded oils through trans esterification, characterization of biodiesel, usage in CI engines with and without retrofitting, algal biodiesel.	6
5.	**Densification:** Densification of agro and forest wastes, technological options, combustion characteristics of densified fuels, usage in boilers, brick kilns and lime kilns.	6
6.	**Efficiency improvement in power generation:** Steam and gas turbine based power generation, cogeneration, IC engines, IGCC and IPCC concepts, supercritical boilers	6

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	and efficiency improvement.	
7.	**Case studies:** Two industrial case studies where waste materials are used to supplement energy needs.	3
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication/ Reprint
1.	Rogoff, M.J. and Screve, F., "Waste-to-Energy: Technologies and Project Implementation", Elsevier Store.	2011
2..	Young G.C., "Municipal Solid Waste to Energy Conversion processes", John Wiley and Sons.	2010
3.	Harker, J.H. and Backhusrt, J.R., "Fuel and Energy", Academic Press Inc.	1981
4.	EL-Halwagi, M.M., "Biogas Technology- Transfer and Diffusion", Elsevier Applied Science.	1984
5.	Hall, D.O. and Overeed, R.P.," Biomass - Renewable Energy", John Willy and Sons.	1987
6.	Mondal, P. and Dalai, A., " Utilization of natural resources" , CRC Press	2017

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Chemical Engineering**

1. Subject Code: **CHE-520** Course Title: **Oil and Gas Transport**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge about the design and engineering problems of transportation of crude oil, petroleum products and natural gas in petroleum industries.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Pipeline Engineering:** An overview, rheology of crude oil and petroleum products, petroleum pipeline construction, safety and environment protection of pipe lines, API and ASTM codes for petroleum, petroleum products and natural gas.	6
2.	**Type of pipes:** Fundamentals, design of pipelines for petroleum and petroleum products, design consideration for buried pipeline and pipeline from tankers to filling stations, flexibility analysis, design of gas pipelines, steel pipe design formula, working pressure of pipe, pipe specifications, complex pipeline systems, storage capacity, two phase flow and heat tracing.	12
3.	**Prime movers, Pumps and Compressors:** Types, selection, characteristics and design.	6
4.	**Corrosion and Aging:** Aging and replacement of piping, control of internal and external pipeline corrosion – detection and prevention, use of coating, additives, anode and cathode protection.	7
5.	**Control and Automation:** Pipeline automation, automatic control schemes, alarms, safety trips and interlocks.	4
6.	**Submarine Pipeline:** Engineering problems, design and construction of submarine pipeline.	4
7.	**Tankers and Rail Transport:** Transportation by tankers and rail.	3

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	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Kennedy J. L., "Oil and Gas Pipeline Fundamentals", 2nd Ed., Pennwell Publication.	1993
2.	Boyd O. B., "Petroleum Fluid Flow Systems", OWB Corporation, John M. Campbell and Co.	1983
3.	Molhatab S., Poe W. A. and Speight J. G., "Handbook of Natural Gas Processing and Tranmission", Gulf Publishing Company.	2006
4.	Nolte C. B., "Optimum Pipe Size Selection", Trans. Tech. Publication.	1978

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-522** Course Title: **Nanotechnology in Chemical Engineering**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7.Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce selected topics in Nanotechnology to Chemical Engineers.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Nanotechnology and its historic perspective, Foundation of nanotechnology in chemistry, physics and biology, nanotechnology in nature.	4
2.	**Nano-structures, nano-materials**: shape and structure of nano-materials: nano-particles, nano-wires, and nano-films, Crystal structure and space lattices, special nano-materials such as quantum dots, semiconductor nano-particles, bio-macromolecules, self assembling nanostructures, nano-structured thin films and nano-composites. Some special nanomaterials: carbon nanomaterials (CNT), Porous material, Aerogels, and Zeolites	6
3.	**Properties of Nano-structures**: Crystal defects, surfaces and interfaces in nanostructures, ceramic interfaces, super-hydrophobic surfaces, thermodynamics of nanostructures, diffusion kinetics, Properties: optical, emission, electronic transport, photonic, refractive index, dielectric, mechanical, magnetic, non-linear optical, catalytic and photo-catalytic	6
4.	**Nano-scale Manufacturing Techniques**: Synthesis of nano-materials: Physical, Chemical and other methods. Bottom up approach: Sol-gel synthesis, hydrothermal growth, thin-film growth, physical vapor deposition, chemical vapor deposition, Top-down-approach: Ball milling, Micro-fabrication, lithography, ion beam lithography	6
5.	**Nano-scale characterization techniques**: X-Ray Diffraction, Brunauer-Emmett-Teller (BET), FTIR, Raman, UV-vis-NIR spectrophotometer analysis, Scanning	8

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	Tunneling Microscope (STM), Atomic Force Microscope (AFM), Field Emission-Scanning Electron Microscopy (FE-SEM), Transmission Electron Microscopy (TEM), Auger Electron spectroscopy (AES), X-Ray Photo-electron Spectroscopy (XPS), Electron Energy Loss Spectroscopy (EELS).	
6.	**Application and Chemical Engineering Aspects:** Flow of nano-fluids in micro-channel, heat transfer from nano-fluids: Convective and radiative, surface energy, colloidal and catalytic behavior of nano-particles, gold nano-particles, nano-particulate suspensions, membrane nanotechnology, nano-engineered catalysts and polymers, nano-material filters.	**12**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	Kulkarni Sulabha K., "Nanotechnology Principles and Practices", 3rd Ed., Capital Publishing Company, New Delhi	2016
2.	Rao, M.S.R, and Singh S., " Nanoscience and Nanotechnology: Fundamentals to Frontiers", Wiley India Pvt. Ltd., I Eds.	2013
3.	Ferry D.K, Goodnick S.M., and Bird J.," Transport in Nanostructure", Cambridge University Press, 2nd Ed.	2009
4.	Banwell Colin N., and McCash Elaine M., " Fundamentals of Molecular Spectroscopy", 5th Ed., McGraw Hill Education (India) Pvt. Ltd, New Delhi	2013

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-524** Course Title: **Microfluidics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To understand the fundamental insights of Microfluidics and microfluidic flows.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Microfluidics; Relationships among microfluidics, nanotechnology and MEMS; Scientific and commercial aspects; Milestones of microfluidics – Device and technology developments; Microfluidics and chemical engineering; Astonishing microfluidics system in nature; Different aspects of microfluidics; Scaling of micromechamical devices	2
2	**Fundamental Physics:** Ranges of forces of microscopic origin; Microscopic scales intervening in liquids and gases; Physics of miniaturization; Miniaturization of electrostatic, electromagnetic, mechanical, thermal and chemical analysis systems; New flow regimes in microfluidics; Continuum hypothesis – molecular magnitude, mixed flow regimes and experimental evidences; Modeling of microfluidic flows; Simulation approaches of microfluidic systems	4
3	**Hydrodynamics of Microfluidic Systems**: Hypothesis of hydrodynamics; Review of hydrodynamics equations, Hydrodynamics of gases in mircosystems; Slip flow and models – general slip conditions, comparison of slip models; Microhydrodynamics; Microfluidics involving inertial effects; Interfacial phenomena; Microfluidics of drops, bubbles and emulsions	6
4.	**Shear- and pressure Driven Microfluidics:** slip and slip flow regimes, transition and free molecular flow regimes; Velocity and shear stress models; Oscillatory Couette flow – steady and unsteady flow; Grooved channel flow, isothermal and adiabatic compressible flows; Entry flows and effects of roughness; Transitional and free-molecular regimes – Burnett equations; Unified flow model;	8

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5.	**Thermal Effects in Microfluidics:** Heat conduction in gases, liquids and solids; Ghost effect; Thermal creep (transpiration); Gas flow at moderate Knudson numbers, convection diffusion equation, heat transfer in presence of flow, Evaporation and boiling, micro-exchangers for electronics.	7
7.	**Electrokinetic flows in Microfluidics:** Electrokinetic effects; Electrical double layer, Potential distribution; Flow characterization and governing equations; Electroosmotic flows – Channel flow, time-periodic flow, EDL/bulk flow interface velocity matching conditions, slip conditions, drag models, Joule heating, applications; Electrophoresis – Classification and governing equations, Taylor dispersion, charged particles in pipe; Dielectrophoresis and its applications	8
8.	**Surface Tension-Driven Flows:** Basic concepts; General form of Young's equations; Governing equations for thin films; Dynamics of capillary spreading; Thermocapillary pumping; Electrocapillary	3
9.	**Micropfabrication and some microfluidic devices**: Photolithography, microfabrication using Silicon and glass, fabrication of microchannels using soft-lithography, examples of microfluidic devices: valves, pumps, connections etc.	4
Total		42

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Suggested References:

S. No.	Name of Books/Authors/Publications	Publication Year
1.	Tabeling P., "*Introduction to Microfluidics*", Oxford University Press	2010
2.	Kandlikar S., Garimella S., Li D., Colin S. and King M.R. "*Heat Transfer and Fluid Flow in Minichannels and Microchannels*", Elseveir	2006
3.	Nguyen N.-T. and Wereley S. "*Fundamental and Applications of Microfluidics*", 2nd Ed. Artech House, London	2006
4.	Kirby B.J. "Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices" Cambridge University Press	2010
5.	Gad-el-Hak, M. "*The MEMS Handbook: Volume 1 – MEMS Introduction and Fundamentals*" 2nd Ed., CRC Press	2006
6.	Karniadakis G., Beskok A. and Aluru N. "*Microflow and Nanoflow: Fundamentals and Simulations*" Springer	2005
7.	Rapp, B.E. "Microfluidics: modeling, mechanics and mathematics" Elsevier	2017
8.	Panigrahi, P.K. "Transport phenomena in microfluidic systems" Wiley	2016

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-526** Course Title: **Supercritical fluids: Theory and Applications**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge supercritical fluids and their applications to chemical engineering processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to Supercritical fluids, Phase diagrams, Thermo-physical properties of SCfs, Supercritical solvents, Phase equilibria (solid and liquid- SCF), Co-solvent effects	8
2.	Solubility Isotherms, P-T impact on solubilities, Selectivity and Solvent capacity, Binary and ternary solubilities, Mixing rules, Modeling of mixture solubility behavior in SCFs	8
3.	Supercrtical carbon dioxide extraction, Natural extracts, Drying of materials, SCFs processing of polymers, SCFs for drug delivery devices, SCFs for particle synthesis	8
4.	Properties of water, Transport and Electric properties of supercritical water, Phase behavior mixtures with SCW, Heat transfer at near and SCW, SCW as reaction medium (Key reactions in SCW)	6
5.	Processing of fuel materials in SCW, Hydrothermal Liquefaction of biomass, Supercritical water Gasification	6
6.	SCW processing of inorganic compounds, Wet air oxidation, Supercritical water oxidation, Hydrothermal flames, Hydrothermal flame oxidation	6
	Total	42

11. Suggested Books:

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S. No.	Name of Books / Authors	Year of Publication
1.	Mukhopadhyay, M. "Natural Extracts using Supercritical Carbon dioxide ", CRC Press	2000
2.	McHugh, M.,, Val Krukonis "Supercritical Fluid Extraction, Principles and Practice" by Mark McHugh, Elsevier, 2nd Edition	2013
3.	Brunner, G., "Hydrothermal and Supercritical water processes" , Volume 5, Elsevier, I st Edition	2014
4.	Edited by Anikeev, V., Fan, M. "Supercritical fluid technology for Energy and Environment Applications", Elsevier	2014

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-528** Course Title: **Introduction to Granular Rheology**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide introductory knowledge of particle technology, specifically hydrodynamics of granular flow with their applications to industrial problems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Overview of importance, techniques and industrial applications of granular rheology	3
2.	**Characterization**: Size Analysis; Processing (Granulation, Fluidization); Particle Formation (Granulation, Size Reduction)	4
3.	**Handling in industry**: Storage and Transport (Hopper Design, Pneumatic Conveying, Standpipes, Slurry Flow; Separation (Filtration, Settling, Cyclones); Safety (Fire and Explosion Hazards, Health Hazard)	8
4.	**Applications and Challenges**: Engineering the Properties of Particulate Systems (Colloids, Respirable Drugs, Slurry Rheology)	8
5.	**General Computational methods:** Overview of various numerical and computational methods applied to granular rheology	10
6.	**Specific examples:** Solved examples from - DEM (soft sphere and hard sphere models), Monte Carlo, Cellular Automata, Lattice-Boltzmann, Kinetic Theory;	9
	Total	42

11. Suggested Books:

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S. No.	Name of Books / Authors	Year of Publication
1.	Rhodes, M.J. "Introduction to Particle Technology", 2nd Edition, and ISBN: 970-470-01428-8, Wiley,	2008
2.	McGlinchey, D. "Characterisation of Bulk Solids", ISBN: 9780849324376, Taylor & Francis Inc,	2005
3	Kesava Rao, K. and Nott, P.R. "An Introduction to granular flow", ISBN: 0511457294, Cambridge University Press	2014
4	Holdich, R. G. "Fundamentals of Particle Technology", ISBN: 0954388100, Midland Information Technology and Publishing	2002
5	Seville, J.P.K., and Wu, C.-Y., "Particle Technology and Engineering: An Engineer's Guide to Particles and Powders: Fundamentals and Computational Approaches", ISBN: 978-0-08-098337-0, Butterworth-Heinemann	2016

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-530** Course Title: **Drug Delivery**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the concepts of drug delivery, modeling of drug delivery systems, and novel drug delivery platforms.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Basic pharmacokinetics and pharmacodynamics, mechanism of drug action, routes of drug delivery, drug exposure and drug response, dosage, bioavailability, toxicity, ADMET, drug screening and drug development	**12**
2.	Single compartment and multi-compartment models, volume of distribution ad rate constants, parameter determination, clinical applications, drug metabolism and elimination	**8**
3.	Controlled/modified/extended/sustained drug release, targeted drug delivery, drug carriers, use of natural and synthetic polymers and nanoparticles, recent advances	**8**
4.	Mass transfer modeling of controlled release systems, Higuchi model and beyond, examples of Fickian and non-Fickian behavior	**6**
5.	In-vitro and in-vivo experiments and modeling, USP apparatus and its applications.	**4**
6.	Molecular simulations in drug delivery, Case studies.	**4**
	Total	**42**

11. Suggested Books:

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S. No.	Name of Books / Authors	Year of Publication
1	Shargel, L., Wu-Pong, S., and Yu, Andrew, Applied Biopharmaceutics and Pharmacokinetics, McGraw Hill, 6th Ed	2012
2	Saltzman, W.M. Drug Delivery: Engineering Principles for Drug Therapy, Oxford University Press, 1st Ed	2001
3	Allen, L. Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems, 11th Ed	2017

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-532** Course Title: **Colloids and Interfacial Science**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To introduce basic concepts of colloidal interactions between surfaces, particles and surfactants and enable students to apply the knowledge in their research problems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Basic concepts of colloids and interfaces:** Introduction; Examples of interfacial phenomenon; Solid fluid interfaces; Colloids: colloids and interfaces; Classification of colloids; Electric charge on colloidal particles; Stability of colloids– kinetic and thermodynamic stabilities; Preparation of colloids; Parameters of colloidal dispersions.	7
2.	**Properties of colloidal dispersions:** Sedimentation under gravity and in a centrifugal field; Brownian motion; Osmotic pressure; Optical properties - light scattering, TEM, SEM, DLS, SANS; Electrical properties: reciprocal relationship and Zeta-potential. Properties of lyophilic sols. Rheological properties of colloidal dispersions – Einstein's equation of viscosity; Mark-Houwink equation of polymer solutions.	8
3.	**Surfactants and their properties:** Surfactants and their properties: anionic surfactants, cationic surfactants, Zwitterionic surfactants, nonionic surfactants, Gemini surfactants and biosurfactants; HLB; Liquid crystals; Micellisation of solutions, thermodynamics of micellisation; Kraft point and cloud points; Emulsions and Microemulsions; Foams.	8
4.	**Surface and interfacial tensions:** Surface tension; Interfacial tension; Contact angle and wetting; Shape of surfaces and interfaces; Measurement of surface and interfacial tension; Measurement of contact angle.	7
5.	**Intermolecular and surface forces:** Van der walls forces; Electrostatic double layer force; DLVO theory; Kinetics of coagulation.	6

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6.	**Characterization of solid surfaces**: Applications in detergents, personal-care products, pharmaceuticals, nanotechnology, food, textile, paint and petroleum industries.	**6**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Hiemenz, P.C. and Rajagopalan, R. "Principles of Colloid and Surface Chemistry", Marcel Dekker, New York, 1997.	1997
2.	Berg, J.C. "An Introduction to Interfaces and Colloids: The Bridge to Nanoscience", World Scientific, Singapore.	2010
3.	Israelachvili, J.N. "Intermolecular and Surface Forces", Third Edition, University of California Santa Barbara, California, USA, Academic Press Elsevier.	2011
4.	Adamson, A.W. and Gast, A.P. "Physical Chemistry of Surfaces", John Wiley & Sons, New York	1997
5.	Myers, D. "Interfaces, and Colloids: Principles and Applications", Wiley, Second Edition, 2002	2002
6.	Hunter, R.J. "Foundations of Colloid Science", Oxford University Press, New York.	2005
7	Russel, W.B., Saville, D.A., Schowalter, W.R. "Colloidal Dispersions", Cambridge University Press	1989

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Chemical Engineering**

1. Subject Code: **CHE-534** Course Title: **Novel Separation Techniques**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge of advance separation processes used in chemical and biochemical industries.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Separation processes in chemical and biochemical industries, categorization of separation processes, equilibrium and rate governed processes.	3
2.	**Membrane Separation:** Membrane materials, Polymeric membranes, Asymmetric and symmetric membranes, Perm-selectivity, Physical factors in membrane separation, Pore size, osmotic pressure, partition coefficient and permeability; Transport through porous membranes- bulk flow, gas diffusion, Knudsen diffusion, liquid diffusion; Transport through nonporous membranes, solution diffusion for liquid mixtures, solution diffusion for gas mixtures, membrane separation factor, ideal membrane separation factor, external mass transfer resistances, concentration polarization and fouling.	8
3.	**Membrane separation processes:** Dialysis, electro-dialysis, reverse osmosis, Gas permeation, pervaporation, Liquid membrane separation.	9
4.	**Adsorption:** Sorbents, adsorbents, surface area and BET equation, Pore volume and distribution, adsorbent materials- silica gel, activated carbon, molecular sieve carbon, molecular sieve zeolite and polymeric adsorbent. **Ion exchange:** Inorganic ion exchangers, Ion exchange resins, ion exchange capacity of resins, anion exchange and cation exchange resins; Ion exchange equilibria. **Chromatography:** Sorbents for chromatography, types of chromatography, ion exchange chromatography, Gel permeation chromatography, application of chromatography.	9
5.	**Adsorption kinetics and thermodynamics:** Adsorption isotherms-	4

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	Freunlich and Langmuir isotherm, gas mixtures and extended isotherms, composite isotherms for binary liquid adsorption.	
6.	**Kinetic and transport considerations in adsorptions:** Convection dispersion model, modes time dependent adsorption- frontal, displacement and differential; internal transport, external transport, effective pore diffusivity; ideal fixed bed adsorption, real fixed bed adsorption-mass transfer zone, breakthrough curves, effect of favorable and unfavorable isotherms, scaling of laboratory experiment using constant pattern front.	**9**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	King C. J., "Separation Processes", Tata McGraw Hill.	1982
2.	Seader J. D. and Henley E. J. "Separation Process Principles", 2nd Ed., Wiley-India.	2006
3.	Basmadjian D., "Mass Transfer and Separation Processes: Principles and Applications", 2nd Ed., CRC.	2007
4.	Khoury F. M., "Multistage Separation Processes", 3rd Ed., CRC.	2004
5.	Wankat P. C., "Separation Process Engineering", 2nd Ed., Prentice Hall.	2006

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-536** Course Title: **Design of Experiments and Parameter Estimation**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge about various techniques of model parameter estimation, analysis and statistical design of experiments.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Strategy of experimentation, basic principles, guidelines for designing experiments;	2
2.	**Simple Comparative Experiments**: Basic statistical concepts, sampling and sampling distribution, inferences about the differences in means, randomized and paired comparison design.	4
3.	**Experiments with Single Factor**: Analysis of variance, analysis of fixed effects model, model adequacy checking, nonparametric methods in analysis of variance.	3
4.	**Design of Experiments:** Randomized blocks, latin squares and related design, factorial design, two-factor factorial design, blocking in a factorial design, the 2^2 and 2^3 factorial design, the general 2^k factorial design, blocking and compounding in the 2^k factorial design, two-level, three level and mixed level factorial and fractional factorial designs.	8
5.	**Parameter Estimation:** Linear regression models, estimation of the parameters in linear regression models, hypothesis testing in multiple regression, confidence intervals in multiple regression, prediction of new response observations, regression model diagnostics, testing for lack of fit.	8
6.	**Response Surface Methods and Other Approaches:** Response surface methodology, method of steepest ascent, analysis of a second-order response surface, experimental designs for fitting response surfaces, mixture experiments, evolutionary operation, robust design; Taguchi's method for optimization of	8

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	experiments.	
7.	**Experiments with Random Factors**: Random effect model, two factor factorial with random factors, two-factor mixed model, sample size determination with random effects, approximate F tests.	**5**
8.	**Design and Analysis:** Nested and split-plot design, non-normal responses and transformations, unbalanced data in a factorial design.	**4**
	Total	**42**

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Lazic Z.R., "Design of Experiments in Chemical Engineering: A Practical Guide", Wiley.	2005
2.	Antony J., "Design of Experiments for Engineers and Scientists", Butterworth-Heinemann.	2004
3.	Montgomery D.C., "Design and Analysis of Experiments", 5th Ed., Wiley.	2004
4.	Roy R.K., "A Primer on the Taguchi method", Society of Manufacturing Engineers.	1990
5.	Roy R.K., "Design of Experiments using the Taguchi Approach: 16 Steps to Product and Process Improvement", Wiley.	2001

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE-538** Course Title: **Industrial Safety and Hazards Management**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide comprehensive knowledge of safety and hazards aspects in industries and the management of hazards.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Industrial processes and hazards potential, mechanical electrical, thermal and process hazards. Safety and hazards regulations, Industrial hygiene. Factories Act, 1948 and Environment (Protection) Act, 1986 and rules thereof.	6
2.	**Fire and Explosion:** Shock wave propagation, vapour cloud and boiling liquid expanding vapours explosion (VCE and BLEVE), mechanical and chemical explosion, multiphase reactions, transport effects and global rates.	8
3.	**Relief Systems:** Preventive and protective management from fires and explosion-inerting, static electricity passivation, ventilation, and sprinkling, proofing, relief systems – relief valves, flares, scrubbers.	8
4.	**Toxicology:** Hazards identification-toxicity, fire, static electricity, noise and dust concentration; Material safety data sheet, hazards indices- Dow and Mond indices, hazard operability (HAZOP) and hazard analysis (HAZAN).	6
5.	**Leaks and Leakages:** Spill and leakage of liquids, vapors, gases and their mixture from storage tanks and equipment; Estimation of leakage/spill rate through hole, pipes and vessel burst; Isothermal and adiabatic flows of gases, spillage and leakage of flashing liquids, pool evaporation and boiling; Release of toxics and dispersion. Naturally buoyant and dense gas dispersion models; Effects	9

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	of momentum and buoyancy; Mitigation measures for leaks and releases.	
6.	**Case Studies:** Flixborough, Bhopal, Texas, ONGC offshore, HPCL Vizag and Jaipur IOC oil-storage depot incident; Oil, natural gas, chlorine and ammonia storage and transportation hazards.	**5**
	Total	**42**

11. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Crowl D.A. and Louvar J.F., "Chemical Process Safety: Fundamentals with Applications", 2nd Ed., Prentice Hall.	2001
2.	Mannan S., "Lee's Loss Prevention in the Process Industries", Vol. I, 3rd Ed., Butterworth-Heinemann.	2004
3.	Mannan S., "Lee's Loss Prevention in the Process Industries", Vol. II, 3rd Ed., Butterworth-Heinemann.	2005
4.	Mannan S., "Lee's Loss Prevention in the Process Industries", Vol. III, 3rd Ed., Butterworth-Heinemann.	2005

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHE- 540** Course Title: **Multiphase flow**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE:40-50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: This course introduces the fundamental concepts, principles and application of multiphase flow.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to multiphase flow, types and applications, Common terminologies, flow patterns and flow pattern maps.	5
2.	Measurement Techniques for experimentalflow	6
3.	One dimensional steady homogenous flow, Analysis of concept of choking and cavitation	4
4.	One dimensional steady separated flow model. Application of separated model for flow with phase change. Application of separated model in analysis of annular and stratified flow	13
5.	General theory of drift flux model. Application of drift flux model to bubbly and slug flow, Modification of Drift flux model for liquid-liquid and gas-liquid flows in mini channels	6
6.	Introduction to three phase flow, applications, flow regime identification, pressure drop and volume fraction estimation techniques	8
	Total	42

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11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Wallis, G.B. "One dimensional Two Phase Flow", McGraw-Hill, New York	1969
2.	Hewitt, G.F., "Measurement of Two Phase Flow Parameters" Academic Press, New York	1979
3.	Ghiaasiaan, S.M. "Two-Phase flow, Boiling, and Condensation in conventional and Miniature Systems", Cambridge University Press	2007
4.	Brennen, C.E. "Fundamentals of Multiphase Flow", Cambridge University Press	2005
5.	Butterworth and Hewitt, "Two Phase Flow and Heat Transfer" , Oxford University Press	1977
6.	Collier, J.G. and Thome, J.R. "Convective Boiling and Condensation", 3rd ed., Oxford University Press	1996

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DEPARTMENT OF CHEMICAL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code	14	M.Tech. (Chemical Engineering)	**Specialization**	None
Department	CH	Department of Chemical Engineering	**Duration**	2 years

Department	Chemical Engineering
Degree Program	**Master of Technology (M.Tech.) in Chemical Engineering**
Specialization	None
Duration	2 years

Course Scheme

First Year		Second Year	
Semester I (Autumn)	**Semester II (Spring)**	**Semester I (Autumn)**	**Semester II (Spring)**
Core Course – I	Elective Course – II		
Core Course – II	Elective Course – III		
Core Course – III	Elective Course – IV		
Core Course – IV	Elective Course – V		
Elective Course – I	Seminar	Dissertation (Stage-I)	Dissertation (Stage-II)
Credits: 20	**18**	**12**	**18**
Total Credits: 68			

Note:

1. Dissertation Stage is continued to next semester
2. Seminar is not necessarily related to the dissertation. Through seminar, student is expected to learn to review the literature and prepare a report as well as presentation in an effective way.
3. There will also be an additional zero-credit course on "Lecture Series" in all semesters. Students will attend the guest lectures in the department. Additional sessions by faculty members of the department will be conducted focussing on research methods on special topics of relevance to chemical engineers, scientific communication, publication process, etc.
4. In addition to above course, students may take one or two audit courses as advised by the supervisor, if required.

DEPARTMENT OF CHEMICAL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code 14 M.Tech. (Chemical Engineering) **Specialization** None

Department CH Department of Chemical Engineering **Duration** 2 years

Year-I

Teaching Scheme					*Contact Hrs. per week*			*Exam Duration*		*Relative Weightage (%)*				
S. No.	**Course Code**	**Course Title**	**Area**	**Credits**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Semester I (Autumn)														
1	CHE-501	Mathematical Methods in Chemical Engineering	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2	CHE-503	Advanced Transport Phenomena	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3	CHE-505	Advanced Reaction Engineering	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4	CHN-507	Advanced Thermodynamics and Molecular Simulations	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
5		Program Elective – I	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
Semester II (Spring)														
1		Program Elective – II	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2		Program Elective – III	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3		Program Elective – IV	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4		Program Elective – V	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
5	CHE-700	Seminar	PEC	2	-	-	-	-	-	-	-	-	100	-

Year-II

Teaching Scheme					*Contact Hrs. per week*			*Exam Duration*		*Relative Weightage (%)*				
S. No.	**Course Code**	**Course Title**	**Area**	**Credits**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Semester I (Autumn)														
1	CHE-701A	Dissertation Stage I	DIS	12	-	-	-	-	-	-	-	-	100	-
Semester II (Spring)														
1	CHE-701B	Dissertation Stage II	DIS	18	-	-	-	-	-	-	-	-	100	-

Summary	Semester	I	II	III	IV
Total Credits: 68	Semester wise total credits	20	18	12	18

DEPARTMENT OF CHEMICAL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Program Code	14	M.Tech. (Chemical Engineering)	**Specialization**	None
Department	CH	Department of Chemical Engineering	**Duration**	2 years

Teaching Scheme					*Contact Hrs. per week*			*Exam Duration*		*Relative Weightage (%)*				
S. No.	**Course Code**	**Course Title**	**Area**	**Credits**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Program Elective – I FOR AUTUMN SEMESTER (Choose ANY ONE Course)														
1	CHE-511	Process Integration	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2	CHE-513	Biochemical Engineering	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3	CHE-515	Computational Fluid Dynamics	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4	CHE-517	Optimization of Chemical Processes	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
Program Elective – II FOR SPRING SEMESTER (Choose ANY FOUR Courses)														
1	CHE-510	Advanced Process Control	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2	CHE-512	Solid and Hazardous Waste Management	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3	CHE-514	Pollution Control Systems	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4	CHE-516	Kinetics of Polymerization	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
5	CHE-518	Waste to Energy Conversion	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
6	CHE-520	Oil and Gas Transport	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
7	CHE-522	Nanotechnology in Chemical Engineering	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
8	CHE-524	Microfluidics	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
9	CHE-540	Multiphase Flow	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
10	CHE-526	Supercritical Fluids: Theory and Applications	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
11	CHE-528	Introduction to Granular Rheology	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
12	CHE-530	Drug Delivery	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
13	CHE-532	Colloids and Interfacial Science	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
14	CHE-534	Novel Separation Techniques	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
15	CHE-536	Design of Experiments and Parameter Estimation	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
16	CHE-538	Industrial Safety and Hazard Management	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-

Appendix 'B'

Item No. Senate/73.7

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

ACADEMIC CALENDAR FOR AUTUMN SEMESTER 2018-19

S.No.	Details	Autumn Semester	
		Date	Day
1.	Reporting and Academic Registration of New PhD students in the Departments/Centres	06.07.2018	Friday
2.	Academic Registration of all new PG/MSc students	09.07.2018	Monday
3.	Re-examination and Second examination for Spring Semester 2017-18	13.07.2018-16.07.2018	Friday-Monday
4.	Academic Registration of all existing students in the Departments/Centres	17.07.2018	Tuesday
5.	Commencement of Classes for all existing students & new PG/MSc/PhD students (2018-19)	18.07.2018	Wednesday
6.	Reporting and Academic Registrations of all new students admitted through JEE	20.07.2018	Friday
7.	Last date of sending the grades of re-examination/second examination	23.07.2018	Monday
8.	Commencement of Classes for all new all new students admitted through JEE	24.07.2018	Tuesday
9.	Last date for Academic Registration	01.08.2018	Wednesday
10.	Last date for addition/deletion of courses	03.08.2018	Friday
11.	Mid Term Examination (MTE) (Excluding Sunday)	14.09.2018 - 18.09.2018	Friday - Tuesday
12.	Mid-Semester Break	19.09.2018 - 23.09.2018	Wednesday-Sunday
13.	Last date for submission of remaining document(s) by all new students	28.09.2018	Friday
14.	Last date for withdrawal of courses	05.10.2018	Friday
15.	Annual Convocation 2018	06.10.2018, 07.10.2018	Saturday Sunday
16.	E-mail notification to the students having short attendance upto 05.11.2018 by the Departments/Centres and to send the Final list to Academic Section	06.11.2018	Tuesday
17.	Last date for Teaching	06.11.2018	Tuesday
18.	End Term Examination (excluding Sunday & holidays) (Practical examinations, if any, may be conducted during last few laboratory classes.)	12.11.2018 - 22.11.2018	Monday-Thursday
19.	Last date for showing End Term Examination Answer Scripts to students	29.11.2018	Thursday
20.	Completion of evaluation of all Projects/ Dissertations/Seminars	29.11.2018	Thursday
21.	Winter vacation for students (except for MTech/ IDD final year and PhD students)	30.11.2018 - 01.01.2019	Friday - Tuesday
22.	Finalization & Dissemination of grades on Channel-I by the Departments	03.12.2018	Monday
23.	Last date to contact departments/centres for grade modification, if any, by students	04.12.2018	Tuesday
24.	Last date for sending final grades to Academic Section after incorporating concerns raised by students, if any	05.12.2018	Wednesday
25.	Last date for submission of progress report of the PhD students to Academic Section by the Departments/Centres	05.12.2018	Wednesday
26.	Period for availing vacation leave by faculty	06.12.2018 - 01.01.2019	Thursday - Tuesday
27.	Last date for applying for Re-Examination	07.12.2018	Friday
28.	Re-examination and Second examination	02.01.2019-03.01.2019	Wednesday-Thursday

23 MAY 2018

Teaching days for Autumn Semester 2018-19 (w.e.f. 18.7.2018 to 06.11.2018)

Days	Months																						Less for MTE/Thomso	Total Teaching days PG (I-yr UG)
	Jul					Aug					Sept				Oct					Nov				
Mon	-	-	-	23	30		6	13	20	27	-	10	**17**	24	1	8	15	22	29		5	**1**	14 (13)
Tues	-	-	-	24	31		7	14	21	28	4	11	**18**	25	-	9	16	23	30		6	**1**	14 (14)
Wed	-	-	18	25		1	8	-	-	29	5	12	-	26	3	10	17	24	31		-	-	13 (12)
Thurs	-	-	19	26		2	9	16	23	30	6	13	-	27	4	11	18	**25 ***		1	-	-	15-1 (14-1)
Fri	-	-	20	27		3	10	17	24	31	7	**14**	-	28	5	12	-	**26**		2	-	**2**	12+1 (11+1)
Sat	-	-	-	**28†**		-	**11†**	-	**25†**		-	**15**	-	-		**13†**	-			-		1	**4†**
Total days	**10+1†**					**21+2†**					**17**				**21**					**4**		**5**	**68 (68)**

***Friday time table will be applicable on 25.10.2018 (Thursday) for all the classes.**

†The following Saturdays would be teaching days **only for I-year BTech/IDD/IMS/IMT/BArch**

28.07.2018 (Saturday) – Friday Time Table
11.08.2018 (Saturday) – Wednesday Time Table
25.08.2018 (Saturday) – Monday Time Table
13.10.2018 (Saturday) – Thursday Time Table

Details of days used in MTE and THOMSO

MTE (September 14 - 18, 2018) - 14.09.2018 - Friday
15.09.2018 - Saturday
17.09.2018 - Monday
18.09.2018 - Tuesday

Thomso (October 26 -28, 2018) - 26.10.2018 - Friday (Non Teaching Working Day)

23 MAY 2018

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ACADEMIC CALENDAR FOR SPRING SEMESTER 2018-19

S.No.	Details	Spring Semester	
		Date	Day
1.	Reporting and Academic Registration of new PhD students in the Departments/Centres	27.12.2018	Thursday
2.	Academic Registration of all existing students in the Departments/Centres	02.01.2019	Wednesday
3.	Re-examination and Second examination (for Autumn Semester 2018-19)	02.01.2019- 03.01.2019	Wednesday- Thursday
4.	Commencement of Classes for all students	03.01.2019	Thursday
5.	Online subject registration of all new PhD students	07.01.2019- 08.01.2019	Monday- Tuesday
6.	Last date for sending the grades of re-examination/second examination	11.01.2019	Friday
7.	Last date for Academic Registration	14.01.2019	Monday
8.	Last date for addition/deletion of courses	15.01.2019	Tuesday
9.	Last date for submission of remaining document(s) by all new PhD students	15.02.2019	Friday
10.	Mid Term Examination (MTE) (Excluding Sunday)	22.02.2019 - 26.02.2019	Friday- Tuesday
11.	Last date for withdrawal of courses	12.03.2019	Tuesday
12.	Mid-Semester Break	18.03.2019- 22.03.2019	Monday- Friday
13.	Completion of evaluation of projects/seminars	18.04.2019	Thursday
14.	E-mail notification to the students having short attendance up to 17.04.2019 by Departments/Centres and to send the Final list to Academic Section	18.04.2019	Thursday
15.	Submission of proficiency grades by all concerned Officers- in-Charges to Academic Section	18.04.2019	Thursday
16.	Last date for Teaching	23.04.2019	Tuesday
17.	End Term Examination (excluding Sunday & holidays) (Practical examinations, if any, may be conducted during last few laboratory classes.)	24.04.2019- 04.05.2019	Wednesday- Saturday
18.	Last date for showing End Term Examination Answer Scripts to students	08.05.2019	Wednesday
19.	Finalization & Dissemination of grades on Channel-I by the Departments	10.05.2019	Friday
20.	Summer Vacation for Students (except for MTech./ IDD Final Year and PhD students)	10.05.2019- 11.07.2019	Friday Thursday
21.	Last date to contact departments/centres for grade modification, if any, by students	13.05.2019	Monday
22.	Last date for sending final grades to Academic Section after incorporating all modifications, if any	14.05.2019	Tuesday
23.	Last date for submission of progress reports of the PhD students to Academic Section by the Departments/Centres	15.05.2019	Wednesday
24.	Last date for applying for re-examination of Spring Semester 2018-19	17.05.2019	Friday
25.	Period for availing vacation leave by faculty	17.05.2019- 11.07.2019	Friday - Thursday
26.	Last date for evaluation & submission of grades for Final Year MTech/ MArch/ MURP/ MTech(ES)/ IDD/IMT Dissertation	28.06.2019	Friday
27.	Reporting and Registration of New PhD students for Autumn Semester 2019-20	05.07.2019	Friday
28.	Re-examination and Second examination	12.07.2019, 15.07.2019	Friday Monday

23 MAY 2018

Teaching days for Spring Semester 2018-19 (w.e.f. 03.1.2019 to 23.4.2019)

Days	Jan					Feb					Mar				Apr					Less for MTE/ CON/	Total teaching days
Monday	-	7	14	21	28	-	4	11	18	**25**	-	11	-	25	1	8	15	22	-	**1**	**13**
Tuesday	-	8	15	22	29	-	5	12	19	**26**	5	12	-	26	2	9	16	23	-	**1**	**14**
Wednesday	-	9	16	23	30	-	6	13	20	27	6	13	-	27	3	10	-	-	-	-	**13**
Thursday	3	10	17	24	31	-	7	14	21	28	7	14	-	28	4	11	**18***	-	-	-	**15**
Friday	4	11	18	25	-	1	8	15	**22**	29	8	**15**	-	29	5	12	-	-	-	**2**	**12**
Saturday									**23**					**30***						**1**	**01**
Total days	21					22					15				15					**5**	**68**

***Friday timetable will be applicable on 30.03.2019 (Saturday)**
***Monday timetable will be applicable on 18.04.2019 (Thursday)**

Details of teaching days used in MTE and COGNIZANCE

MTE (February 22-26, 2019) - 22.02.2019 – Friday
23.02.2019 –Saturday
25.02.2019 –Monday
26.02.2019 – Tuesday

COGNIZANCE (March 15-17, 2019) - 15.03.2019 – Friday (Non Teaching Working Day)

23 MAY 2018

Appendix – A1

No. ____

PROVISIONAL DEGREE CERTIFICATE

This is to certify that **Mr.** _____ (En.No._____) has completed his research work for the award of Ph.D. degree. His viva-voce examination was held on **May 10, 2018** and he has successfully completed the requirements prescribed under the regulations for the award of Ph.D. degree. The topic of his Ph.D. thesis is"_____".

Assistant Registrar
(Evaluation)

Dated: **May 16, 2018**

Note: The above Research Scholar has qualified for the Ph.D. degree which will be awarded to him/her in the ensuing Convocation of the Institute. This provisional certificate is valid till Degree Certificate is awarded in the ensuing convocation of the Institute.

23 MAY 2018

Serial No. 171928

Appendix – A2

Enrolment No. 12914031

भारतीय प्रौद्योगिकी संस्थान रुड़की

अभिषद् की अनुशंसा पर

विद्या वाचस्पति

की उपाधि

अभिषेक जिन्दल

को

शोध प्रबन्ध शीर्षक: इनक्लूशन ऑफ रिसाईकल्ड कंक्रीट एग्रीगेट्स एंड मिनरल एडमिक्सचर्स इन पीक्यूसी मिक्स

भारतीय गणराज्य के अन्तर्गत रुड़की में आज, दिनांक सितम्बर 24, 2017, संस्थान की मुद्रा अंकित यह उपाधि दी गई।

Hologram

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

on the recommendation of the Senate hereby confers the degree of

Doctor of Philosophy

upon

ABHISHEK JINDAL

Thesis Title: INCLUSION OF RECYCLED CONCRETE AGGREGATES AND MINERAL ADMIXTURES IN PQC MIX

Given this day, September 24, 2017, under the seal of the Institute at Roorkee in the Republic of India.

23 MAY 2018

कुलसचिव
Registrar

अध्यक्ष अभिषद् एवं निदेशक
Chairman Senate & Director

Senate Approved 68 PDC List:

S.No.	Name	Deptt.	Topic	Supervisor	Examiner (For./Ind.)	PDC Date
1	Mr. Anant Kumar Rai	AHEC	HYDRO-ABRASIVE EROSION OF PELTON TURBINES	Dr. Arun Kumar Dr. Thomas Staubil	Prof. Mette Eltvik, Norway Prof. S. N. Singh, IIT Delhi Prof. M. Kamaraj, IIT Madras	07.03.18
2	Mr. Utkarsh Singh	AHEC	DETECTION AND CLASSIFICATION OF POWER QUALITY DISTURBANCES	Dr. S. N. Singh	Prof. Gerald Thomas Heydt, USA Prof. Bhim Singh, IIT Delhi Prof. S. C. Srivastava, IIT Kanpur	11.02.18
3	Mr. Ravi Kant Ravi	AHEC	STUDY OF DOUBLE PASS ROUGHENED SOLAR AIR HEATER WITH DISCRETE MULTI V-SHAPED AND STAGGERED RIBS	Dr. R. P. Saini	Prof. Mohammad E. Taslim, USA Prof. K. Srinivas Reddy, IIT Madras Prof. P. Muthukumar, IIT Guwahati	09.02.18
4	Ms. Meenakshi Sharma	BT	BIOPHYSICAL STUDIES ON STRUCTURAL TRANSITIONS OF T7 BACTERIOPHAGE ENDOLYSIN	Dr. K. M. Poluri	Prof. France Separovic , Australia Prof. A. Gopala Krishna , IIT Madras Dr. Ashutosh Kumar, IIT Bombay	01.03.18
5	Mr. Sarkate Amol Vitthalrao	BT	BIOCHEMICAL AND MOLECULAR ANALYSES OF PHYTOALEXIN BIOSYNTHESIS IN APPLE CELL CULTURES	Dr. Debabrata Sircar	Prof. Henryk Flachowsky, Germany Dr. Vineet Kumar, FRI Dehradun Dr. Sharad Srivastava, CSIR Lucknow	26.02.18
6	Mr. Rajesh Sharma	BT	STRUCTURAL AND FUNCTIONAL STUDIES OF CHIKUNGUNYA VIRUS CAPSID PROTEIN	Dr. Shailly Tomar	Prof. R. J. Kuhn, USA Prof. Ruchi Anand, IIT Bombay Prof. S. Yadav, AIIMS Dew Delhi	16.01.18
7	Mr. Shashank Sagar Saini	BT	BIOSYNTHESIS OF BENZOATE-DERIVED BIPHENYL PHYTOALEXINS IN CELL CULTURES OF *Pyrus pyrifolia*	Dr. Debabrata Sircar	Prof. R. Hansch, Germany Prof. A. Mitra, IIT Kharagpur Dr. Vineet Kumar, FRI Dehradun	11.01.18
8	Mr. Ram Pravesh Ram	CH	PERIODIC FLOW OF NON-NEWTONIAN FLUIDS ACROSS AN ARRAY OF CYLINDERS	Dr. A. K. Dhiman Dr. R. P. Bharti	Prof. Andrew Martin, Sweden Prof. P. S. Ghoshdastidar, IIT Kanpur Prof. R. P. Chhabra, IIT Kanpur	05.02.18
9	Mr. Anil Kumar Verma	CH	PYROLYSIS KINETICS OF BIOMASS FEEDSTOCKS AND BIO-OIL PRODUCTION	Dr. Prasenjit Mondal	Prof. Ajay K. Dalai, Canada Prof. B. C. Meikap, IIT Kharagpur Prof. Kaustubha Mohanty, IIT Guwahati	24.01.18
10	Mr. Kartikeya Shukla	CH	STUDIES ON THE SYNTHESIS OF CATALYSTS FOR DIETHYL CARBONATE PRODUCTION	Dr. V. C. Srivastava	Prof. Paolo De Filippis, Italy Prof. A. S. K. Sinha, IIT (BHU) Varanasi Prof. Giridhar Madras, IISc Bangalore	12.04.18
11	Mr. Vijay Kumar Verma	CH	THE DEVELOPMENT OF MESHLESS LOCAL PETROV GALERKIN (MLPG) METHOD FOR COMPLEX FLUID FLOW SIMULATION	Dr. Ram Prakash Bharti	Prof. S. N. Atluri, USa Prof. R. P. Chhabra, IIT Kanpur	23.04.18
12	Ms. Shaily	CY	DESIGN, SYNTHESIS AND CHARACTERISATION OF COUMARIN DERIVATIVES AS CHEMOSENSORS	Dr. Naseem Ahmed Dr. Anuj Sharma	Prof. Mushfiquddin Khan, USA Prof. Faiz Ahmed Khan, IIT Hyderabad Prof. Abu T. Khan, IIT Guwahati	31.01.18

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13	Ms. Nirma Maurya	CY	SYNTHESIS OF SOME NOVEL CHEMICAL SENSOR FOR CYANIDE ION SENSING *VIA* DIFFERENT MECHANISM	Dr. A. K. Singh	Prof. Munetka Oyama, Japan Prof. P. S. Pandey, Noida Prof. R. M. Singh, IS Varanasi	26.02.18
14	Mr. Shiv Kumar Alwera	CY	RESOLUTION OF CERTAIN RACEMIC PHARMACEUTICALS BY LIQUID CHROMATOGRAPHY	Dr. Ravi Bhushan	Prof. Teresa Kowalska, Poland Prof. A. K. Singh, IIT Delhi Prof. P. K. Sharma, JNU Jodhpur	23.04.18
15	Mr. Ovender Singh	CY	SYNTHESIS AND CHARACTERIZATION OF SOME TRANSITION METAL COMPLEXES AND THEIR REACTIVITY STUDIES	Dr. Kaushik Ghosh	Prof. Antonio Rosato, Italy Prof. Ajay Kumar singh, IIT Delhi Prof. G. K. Lahiri, IIT Bombay	2304.18
16	Mr. Siddharth Mehndiratta	CE	ANALYSIS OF SHALLOW FOUNDATIONS ON PARTIALLY SATURATED SOILS	Dr. V. A. Sawant	Prof. Prabir K. kolay, USA Prof. D. M. Dewaikar, IIT Bombay Prof. G. R. Dodagoudar, IIT Madras	09.03.18
17	Mr. Deepak Singh	CE	ASSESSMENT OF WATER-ICE ON LUNAR SURFACE USING CHANDRAYAAN AND TERRESTRIAL DATA	Dr. R. D. Garg Dr. P. K. Garg	Prof. Rudiger Gens, USA Dr. R. S. Chatterjee, IIRS Dehradun Prof. Onkar Dikshit, IIT Kanpur	01.03.18
18	Mr. Sapkal Vaibhav Rajiv	CE	TREATMENT OF MUNICIPAL SOLID WASTE LEACHATE	Dr. Pradeep Kumar Dr. Atul N. Vaidya Dr. M. K. Chandel	Prof. J. P. Hettiaratchi, Canada Prof. Babu Alappat, IIT Delhi Prof. P. K. Mishra, IIT (BHU) Varanasi	24.01.18
19	Mr. Upendra Nath Mishra	CE	A COMPARATIVE EVALUATION OF METHODS FOR DEVELOPMENT OF INDIAN GEOID MODEL	Dr. J. K. Ghosh	Prof. Rene Forsberg, Denmark Prof. B. Nagarajan, IIT Kanpur Dr. Bijendra singh, Hyderabad	16.01.18
20	Mr. Bhupendra Singh	CE	LINEAR AND NONLINEAR VISCOELASTIC ANALYSIS OF AGED ASPHALT BINDERS	Dr. Praveen Kumar	Prof. Alan Carter, Cnada Dr. Rajan Choudhary, IIT Guwahati Dr. D. Tiwari, CSIR New Delhi	11.01.18
21	Mr. Murtaza Hasan	CE	BEHAVIOUR OF FLOATING GRANULAR PILES IN SOFT SOILS	Dr. N. K. Samadhiya	Dr. V. Sivakumar, UK Prof. K. Rajahopal, IIT Madras Dr. Sujit K. Dash, IIT Kharagpur	08.04.18
22	Ms. Mansha Swami	CE	OPERATIONAL AND SPATIAL EFFECTIVENESS OF MULTIMODAL TRANSPORTATION SYSTEMS	Dr. M. Parida	Prof. Rae J. Hurlonge, Tobago Prof. Sunder Lall Dhingra, Mumbai Prof. Sudip Kumar Roy, IIEST Shibpur	21.03.18
23	Ms. Arpita Saha	CE	MEASUREMENT AND ANALYSIS OF DELAY AT SIGNAL CONTROLLED INTERSECTIONS	Dr. Indrajit Ghosh Dr. Satish Chandra	Prof. Timothy Gates, USA Prof. F. A. Kidwai, JMI Delhi	25.03.18
24	Mr. Naveen Chandra	CE	A COGNITIVE METHOD FOR OBJECT DETECTION FROM SATELLITE IMAGES	Dr. J. K. Ghosh	Prof. Shawn Newsam, USA Prof. Onkar DDikshit, IIT Kanpur Dr. Sruya S. Burbha, IIT Bombay	02.04.18
25	Mr. Siddhartha Pandey	CE	STUDIES ON A TWO-PHASE ANAEROBIC BIOFILM REACTOR	Dr. Sudipta Sarkar	Prof. Devendra P. Saroj, UK Prof. Ligy Philip, IIT Madras	19.04.18
26	Mr. Mitesh Surana	EQ	SEISMIC VULNERABILITY OF HILL BUILDINGS	Dr. Yogendra Singh Dr. Dominik H. Lang	Prof. Dina D'Ayala, UK Prof. A. K. Nagpal, Delhi Prof. R. S. Jangid, IIT Bombay	21.02.18

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27	Mr. Vijay Sharma	ES	TECTONIC EFFECTS ON GEOMORPHOLOGY AND SEDIMENTATION IN PARTS OF WESTERN BASTAR CRATON	Dr. Pitambar Pati	Prof. M. Ren, USA Dr. K. R. Randive, NU Nagpur Prof. S. Goswami, SU Odisha	28.02.18
28	Mr. Susanta Borgohain	ES	BRAHMAPUTRA RIVER MORPHOLOGY IN UPPER ASSAM AND SEISMOTECTONIC RELATIONS	Dr. A. K. Saraf Dr. Josodhir Das	Prof. A. Tronin, Russia Prof. Jayanta K. PatiUA Allahabad	02.04.18
29	Mr. Sarangthem Sanajaoba Singh	EE	SIMULATED PERFORMANCE OF A HYBRID ENERGY SYSTEM FOR A REMOTE AREA	Dr. E. Fernandez	Prof. A. Kalam, Aistralia Prof. Sukumar Mishra, IIT Delhi Prof. S. Iniyan, AU Chennai	12.03.18
30	Mr. Afroz Alam	EE	OPTIMAL PLACEMENT OF PROTECTIVE DEVICES IN DISTRIBUTION SYSTEM	Dr. Vinay Pant	Prof. Elham Makram, USA Prof. S. C. Srivastava, IIT Kanpur	19.04.18
31	Mr. Repaul Kanji	EDMM	A STUDY ON DEVELOPING DISASTER RESILIENCE THROUGH CORPORATE SOCIAL RESPONSIBILITY	Dr. Rajat Agarwal	Prof. Rajib Shaw, Japan Dr. S. Sahney, IIT Kharagpur Prof. Mihir R. Bhatt, Ahmedabad	03.04.18
32	Mr. Prateek Dolas	ECE	ENERGY EFFICIENT COMPRESSIVE DATA GATHERING IN WIRELESS SENSOR NETWORKS	Dr. Debashis Ghosh	Prof. J. Ben-Othman, France Dr. Vimal Bhatia, IIT Indore Dr. P. Rajalakshmi, IIT Hyderabad	01.02.18
33	Ms. Ankita Jain	ECE	SAR DATA ANALYSIS FOR LAND COVER CLASSIFICATION AND SOIL MOISTURE RETRIEVAL	Dr. Dharmendra Singh	Prof. Jasmeet Judge, USA Prof. K. P. Singh, IIT (BHU) Varanasi Prof. T. N. Singh, IIT Bombay	27.12.17
34	Mr. Bambam Kumar	E&CE	HIDDEN OBJECT DETECTION WITH MICROWAVE AND MILLIMETER WAVE IMAGING SYSTEM	Dr. Dharmendra Singh	Prof. Hirokazu Kobayashi, Japan Prof A. R. Harish, IIT Kanpur Prof. S. N. Marchant, IIT Bombay	02.04.18
35	Mr. Amit Kumar Singh	IIC	A STUDY ON THE MAGNETIC BEHAVIOR OF DOUBLE PEROVSKITE NANOSTRUCTURES	Dr. Ramesh Chandra	Prof. Ganpati Ramanath, USA Dr. V. Adyam, IIT Kharagpur Prof. Sujeet Chaudhary, IIT Delhi	23.01.18
36	Mr. Ashwani Kumar	IIC	NANOSTRUCTURED METAL OXIDE BASED ELECTRODE MATERIALS FOR SUPERCAPACITORS	Dr. Ramesh Chandra	Prof. Fernando Calle Gomez, Spain Prof. S. A. Hashmi, DU Delhi Prof. Rajiv Prakash, IIT (BHU) Varanasi	24.04.18
37	Mr. Sovan Chakraborty	HSS	DIALECTICS OF MODERNITY: A STUDY OF AMIT CHAUDHURI'S SELECT FICTIONS	Dr. Nagendra Kumar	Prof. B. P. D. O. Connor, Ireland Prof. T. Ravichandran, IIT Kanpur Prof. Surya Nath Pandey, BHU Varanasi	21.03.18
38	Ms. Sukanya Mondal	HSS	EXAMINING SUBALTERN AGENCY IN AMITAV GHOSH'S NOVELS	Dr. Rashmi Gaur	Prof. Nalini Iyer, USA Dr. Debjani Sengupta, ICW, Delhi Dr. Rajni Singh IIT Dhanbad	02.04.18
39	Mr. Mayank Yadav	DoMS	EFFECT OF SOCIAL MEDIA MARKETING ACTIVITIES ON CUSTOMER LOYALTY IN E-COMMERCE INDUSTRY	Dr. Z. Rahman	Prof. Chan Tung Sun, Hong Kong Prof. K. M. Baharul Islam, IIM Kashipur Prof. Ashwani Kumar, IIM Lucknow	23.04.18
40	Mr. Jamid Ul Islam	DoMS	INVESTIGATING THE EFFECT OF ONLINE BRAND COMMUNITY CHARACTERISTICS ON CUSTOMER ENGAGEMENT	Dr. Z. Rahman	Prof. Chan Tung Sun, Hong Kong Prof. Om Prakash Wali, New Delhi Prof. Ashwani Kumar, IIM Lucknow	24.04.18

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41	Mr. Mohammad Faraz Naim	DoMS	ENABLERS OF RETENTION OF GEN Y TALENT: A STUDY OF IT INDUSTRY IN INDIA	Dr. Usha Lenka	Prof. Thomas Garavan, UK Prof. Kanika T. Bhal, IIT Delhi Prof. Shailendra Singh, IIM Raanchi	26.03.18
42	Ms. Shampy Kamboj	DoMS	MODELLING AND MEASURING OF CUSTOMER PARTICIPATION IN SOCIAL MEDIA BRAND COMMUNITIE	Dr. Z. Rahman	Prof. Roubaud David, France Prof. Om Prakash Wali, New Delhi Prof. Devashish D. Gupta, IIM Lucknow	25.04.18
43	Mr. Bimal Mandal	MA	ON BOOLEAN BENT FUNCTIONS AND THEIR GENERALIZATIONS	Dr. S. Gangopadhyay	Prof. M. G. Parkaer, Norway Prof. Subhamoy Maitra, ISI Kolkata Dr. D. K. Dalai, NISER Bhubaneswar	15.02.18
44	Ms. Manjari Sidharth	MA	STUDY ON CONVERGENCE OF CERTAIN LINEAR POSITIVE OPERATORS	Dr. P. N. Agarwal	Prof. R. N. Mohapatra, USA Dr. Naokant Deo, New Delhi Prof. Abdul Wafi, New Delhi	18.01.18
45	Ms. Sumana Ghosh	MA	MATHEMATICAL MODELS OF HUMORAL AND CELL MEDIATED IMMUNE RESPONSES - A COMPARATIVE STUDY	Dr. Sandip Banerjee	Prof. Seyed Moghadas, Canada Dr. S. P. Chakrabarty, IIT Guwahati Prof. Balram Dubey, BITS Pilani	12.03.18
46	Ms. Kavita Gupta	MA	DESIGN AND APPLICATIONS OF SPIDER MONKEY OPTIMIZATION	Dr. Kusum Deep	Prof. Atulya K. Nagar, UK Prof. Samrat L. Sabat, UH Hyderabad Prof. A. K. Ojha, IIT Bhubaneswar	21.03.18
47	Mr. Abhishek K. Sharma	MA	STABILITY OF MIXED CONVECTION FLOW IN VERTICAL CHANNEL FILLED WITH POROUS MEDIUM	Dr. P. Bera	Dr. Antonio Barletta, Italy Prof. G. P. Raja Sekhar, IIT Kharagpur Prof. K. Muralidhar, Iit Kanpur	24.04.18
48	Mr. Sumit Malik	MA	NUMERICAL STUDY OF HEAT TRANSFER AND ENTROPY GENERATION IN NANOFLUID FILLED ENCLOSURE	Dr. A. K. Nayak	Prof. Ashok Singh, Denmark Dr. P. A. Lakshmi Narayan, IIT Hyderabad	20.03.18
49	Ms. Indira Priyadarshini Debnath	MA	ON EFFICIENCY AND DUALITY FOR SOME VECTOR OPTIMIZATION PROBLEMS	Dr. S. K. Gupta	Prof. Ioan M. Stancu-Minasian, Romania Prof. Bhaba K. Mohanty, IIM Lucknow	08.04.18
50	Ms. Pooja Gupta	MA	STUDY OF THE RATE OF CONVERGENCE OF CERTAIN LINEAR POSITIVE APPROXIMATION METHODS	Dr. P. N. Agarwal	Prof. Voichita Adriana Radu, Romania Prof. M. Mursaleen, AMU Aligarh Prof. Vijay Gupta, NSIT, New Delhi	25.04.18
51	Ms. Trapti Neer	MA	INTEGRAL MODIFICATION OF CERTAIN POSITIVE LINEAR OPERATORS	Dr. P. N. Agarwal	Prof. R. N. Mohapatra, USA Prof. Naokant Deo, Delhi	11.04.18
52	Mr. Rakesh K. Meena	MA	QUEUEING MODELING OF REPAIRABLE MACHINING SYSTEMS WITH SERVICE INTERRUPTIONS	Dr. Madhu Jain	Prof. Tuan Phung-Duc, Japan Prof. U. C. Gupta, IIT Kharagpur	30.04.18
53	Mr. P. Sudhakar Rao	MIE	STUDIES ON ELECTRO CHEMICAL HONING OF EXTERNAL CYLINDRICAL SURFACES	Dr. D. K. Dwivedi Dr. P. K. Jain	Prof. Mustafizur Rahman, Singapore Prof. Uday Shanker Dixit, IIT Guwahati Prof. Manoj K. Tiwari, IIT Kharagpur	08.03.18

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54	Mr. Prakash Kumar	MIE	MODELLING OF HUMAN INDUCED FORCE ON STRUCTURES	Dr. Anil Kumar	Prof. Oreste S. Bursi, Italy Prof. S. K. Deb, IIT Guwahati Prof. Pradeep Yammiyavar, IIT Kuwahati	09.03.18
55	Mr. Ravi Shanker Vidyarthy	MIE	STUDIES ON ACTIVATED FLUX GAS TUNGSTEN ARC WELDED JOINTS OF STEELS	Dr. D. K. Dwivedi	Prof. Pasquale Russo Spena, Italy Prof. Amitava De, IIT Mumbai Prof. Ashish Kumar Nath, IIT Kharagpur	07.02.18
56	Mr. Sobhit Saxena	MME	LITHIUM ION BATTERY-SUPERCAPACITOR HYBRID USING BIMATERIAL ELECTRODES	Dr. Anjan Sil	Prof. Giovanni Zangari, USA Dr. Sagar Mitra, IIT Bombay	07.02.18
57	Mr. Yashwant Mehta	MME	THERMO-MECHANICAL PROCESSING AND MECHANICAL BEHAVIOUR OF HIGH PHOSPHOROUS STEELS	Dr. G. P. Chaushari Dr. V. V. Dabhade	Prof. W. Stumpf, South Africa Dr. S. V. S. N. Murty, Trivandrum	05.02.18
58	Mr. Neeraj Srivastava	MME	ULTRASONIC PROCESSING OF ALUMINIUM ALLOY MELTS	Dr. G. P. Chaudhari	Prof. T. S. Srivatsan, USA Prof. S. Aravindan, IIT Delhi	08.04.18
59	Mr. Ramkishor	MME	ULTRA-NARROW GAP P-GMA WELDING FOR THICK SECTION OF 304LN STAINLESS STEEL TO HSLA STEEL	Dr. P. K. Ghosh	Dr. Ing Habil Fussel, Germany Prof. Amitava De, IIT Bombay Dr. G. Madhusudhan Reddy, Hyderabad	20.03.18
60	Ms. Snehalatha L.	NT	INVESTIGATIONS ON CONCURRENT MULTI-BAND RF CIRCUITS FOR WIRELESS APPLICATIONS	Dr. N. P. Pathak Dr. Sanjeev K. Manhas	Prof. Arokiaswami Alphones, Singapore Dr. M. Jaleel Akhtar, IIT Kanpur	27.04.18
61	Mr. Neeraj Gill	NT	DEVELOPMENT OF FSS EMBEDDED MULTILAYER NANOCOMPOSITE FOR MICROWAVE ABSORPTION	Dr. Dharmendra Singh	Prof. Yoshio Yamaguchi, Japan Prof. A. Chakrabarty, IIT Kharagpur	24.04.18
62	Ms. Ankita Gaur	PH	STUDIES ON MULTI-MODE ERBIUM DOPED FIBER AMPLIFIER	Dr. Vipul Rastogi	Prof. Philippe Roy, France Prof. R. K. Shevgaonkar, IIT Bombay Prof. R. K. Varshney, IIT Delhi	06.02.18
63	Ms. Mahima Arya	PH	PLASMONIC PROPERTIES OF CLOSELYSPACED METALLIC NANOISLANDS THIN FILMS	Dr. Anirban Mitra Dr. R. Nath	Prof. Anatoly Pinchuk, USA Dr. B. Tirumala Rao, RRCAT Indore	07.02.18
64	Mr. Avijeet Ray	PH	FIRST PRINCIPLES STUDY OF TRANSPORT AND MAGNETIC PROPERTIES IN CERTAIN CORRELATED MATERIALS	Dr. Tulika Maitra	Prof. Maria-Poser Valenti, Germany Dr. Jiji Pilikkoti, New Delhi Prof. Tarun Kanti Ghosh, IIT Kanpur	15.03.18
65	Mr. Karunava Sil	PH	APPLICATIONS OF TOP-DOWN HOLOGRAPHIC THERMAL QCD AT FINITE COUPLING	Dr. Alok Misra	Prof. Niels A. Obers, Denmark Dr. Arnab Kundu, SINP Kolkata	26.03.18
66	Mr. Suryakant	PPE	CLUSTERING BASED COLLABORATIVE FILTERING APPROACH TO ALLEVIATE DATA SPARSITY	Dr. Tripti Mahara	Prof. Ajith Abraham, USA Prof. P. K. Kapur, AU Noida Dr. Pradip K. Bala, IIM Ranchi	11.01.18

67	Mr. Sushil Kumar Himanshu	WRDM	EVALUATION OF SATELLITE-BASED PRECIPITATION ESTIMATES FOR HYDROLOGICAL MODELLING	Dr. Ashish Pandey	Prof. Nicola Fohrer, Germany Prof. Shashi Mathur, IIT Delhi Prof. N. S. Raghuwanshi, MANIT Bhopal	18.01.18
68	Mr. Brij Kishor Pandey	WRDM	HYDROLOGICAL RESPONSE SIMULATION UNDER LAND USE AND CLIMATE CHANGE SCENARIOS	Dr. Deepak Khare	Prof. Chris S. Renschler, USA Prof. B. R. Chahar, IIT Delhi Prof. Eldho T. I., IIT Bombay	02.04.18

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