Minutes of Meeting

14th Meeting *of the* Senate

Venue of the Meeting

Conference Hall, IIPE, Visakhapatnam &
Virtually through CISCO Webex

Date & Time of the Meeting

27th October, 2025 at 11:30 AM

INDIAN INSTITUTE OF PETROLEUM AND ENERGY
VISAKHAPATNAM – 530003

भारतीय पेट्रोलियम और ऊर्जा संस्थान विशाखापत्तनम

INDIAN INSTITUTE OF PETROLEUM AND ENERGY
VISAKHAPATNAM – 530 003

MINUTES OF THE 14th MEETING OF THE SENATE OF IIPE VISAKHAPATNAM

Date & Time: 27th October, 2025 (Monday) from 11:30 AM

Venue: Conference Hall (Room No. 301), IIPE Campus, Visakhapatnam & virtually through CISCO Webex.

Members Present:

1	Prof. Shalivahan, Director	Chairperson	Attended Physically
2	Prof. Arvind Kumar Mishra, Director, CSIR-CIMFR Dhanbad	Member	Attended Virtually
3	Prof. K. Srinivas Reddy, IIT Madras	Member	Attended Virtually
4	Shri Binayananda Bharali	Member	Attended Virtually
5	Prof. A. Seshagiri Rao, Assoc. Dean (Faculty Affairs)	Member	Attended Virtually
6	Prof. Himangshu Kakati, Assoc. Dean (Academic Affairs) & HoD (PE&ES)	Member	Attended Physically
7	Prof. C.V. Rao, Assoc. Dean (Students' Affairs)	Member	Attended Virtually
8	Prof. Rajat Jain, Assoc. Dean (IRAA)	Member	Attended Physically
9	Prof. Arun Kumar Pujari, HoD, Mechanical Engineering	Member	Attended Physically
10	Prof. P. Venkata Reddy, HoD, Chemical Engineering	Member	Attended Virtually
11	Prof. R. Ramunaidu, Dept. Humanities & Sciences	Member	Attended Virtually
12	Prof. Dipankar Pal, Dept. Chemical Engineering	Member	Attended Virtually
13	Prof. K. Vijaya Kumar, Dean (Research & Development)	Member	Attended Virtually
14	Prof. Somnath Ghosh, HoD, Humanities & Sciences	Member	Attended Physically
15	Prof. P. Aparoy, Assoc. Dean (Research & Development)	Member	Attended Virtually
16	Prof. Sivasankar P., Assoc. Dean (Planning)	Member	Attended Virtually
17	Shri Ram Phal Dwivedi, Registrar	Ex-officio Secretary	Attended Physically

Leave of Absence has been recorded for the following:

1	Prof. Ranjan Pramanik, Assoc. Dean (IIE)	Member
2	Prof. T. Hemanth Kumar, Dept. Chemical Engineering	Member
3	Prof. Raka Mondal, Dept. Chemical Engineering	Member

At the outset, the **Chairman welcomed all members of the Senate**, expressed appreciation for their valuable contributions to the academic and research activities of the Institute.

After ascertaining the quorum, the Chairman declared the meeting open. The following agenda was transacted.

Senate/14/01	**Confirmation of the minutes of the 13th meeting of the Senate held on 16th May, 2025.**

The Minutes of the 13th Senate Meeting held on 16.05.2025 were circulated to all members. No comments or modifications were received.

Resolution: The Senate resolved to confirm the Minutes of the 13th Meeting.

Senate/14/02	**Submission of the Action Taken Report on the Resolutions of the 13th Senate Meeting held on 16th May, 2025**

The Action Taken Report (ATR) on the resolutions of the 13th meeting was presented before the Senate.

Resolution: The Senate noted the ATR with satisfaction.

Senate/14/03	**Announcements by the Director, if any.**

The Director briefed the Senate on the key academic and institutional developments during the current academic year as follows:

New Academic Programs: The Institute has introduced B.Tech. in Mathematics and Computing and M.Tech. in Petroleum Engineering this year.

Admissions: Out of 162 sanctioned seats, 154 B.Tech. students were admitted. A few ST seats remained vacant. Subsequently, four students opted out, and the present B.Tech. strength stands at 150. Additionally, 14 students were admitted to the M.Sc. in Applied Geology program. The newly started M.Tech. in Petroleum Engineering program admitted 3 students this year. The Ph.D. program received 18 admissions, including five industry-sponsored candidates. The Institute also initiated a Post-Doctoral Fellowship program, and three fellows have joined.

Placements and Internships: The Institute recorded 97% placement for B.Tech. students, 87% for Masters students and 100% Internship assistance to all pre-final year students. The Director appreciated the commendable efforts of the Career Development Cell (CDC) team.

Rankings: The Institute participated for the second time in the NIRF Rankings 2025 and continued to be placed in the 201–300 band.

Infrastructure: The Institute plans to commence academic activities at the permanent campus from 5th January 2026, and the shifting process is scheduled to begin by the end of November 2025.

Research and Development: Two design patents were granted to Prof. Santosh Kumar Senapathi and Prof. Arun Kumar Pujari. Currently, there are 25 ongoing projects with a project outlay of about ₹50 crores.

Workshops and Events: Significant events conducted during the period included, (i) HR Conclave (6th September 2025) on "Bridging Talent, Technology, and Industry Expectations in Energy and Engineering" with the Director. H.R. (HPCL) as the Chief Guest; (ii) Training Program on COMSOL Multiphysics; (iii) Workshop on World Environment Day titled "Awareness: The Key to Building a Greener Tomorrow."

The Director appreciated and congratulated Prof. K. Vijaya Kumar and Prof. Roshan Singh for successfully organizing Conference on Natural Hydrogen, which received national-level recognition. Following their presentation at NITI Aayog, a concept paper and budget proposal were submitted towards establishing a National Mission on Natural Hydrogen.

The Senate commended their efforts in positioning the Institute as a think tank for the Government of India in advancing national energy initiatives.

Resolution: The Senate noted the Director's report with appreciation.

Senate/14/04	**Four-year curriculum (3-8 Sem) for the B.Tech. program in Mathematics and Computing**

The four-year curriculum (3rd to 8th Semesters) for the B.Tech. program in Mathematics and Computing was placed before the Senate for consideration and approval.

The Senate was apprised that during its 7th meeting, 03 IC courses were approved to offer during the 3rd semester for all B.Tech. Courses. Presently, the following 03 IC courses are being offered in the Petroleum, Chemical and Mechanical streams:

(i) Numerical Methods & Transform Calculus;
(ii) Object-Oriented Programming;
(iii) Fluid Mechanics.

Considering the above, the Senate opined that for B.Tech. in Mathematics & Computing, the department may offer any 02 Institute Core (IC) courses from the above listed 03 ICs and the 3rd relevant course can be opted by the department.

Further, the Senate recommended for inclusion of one additional laboratory course, thereby standardizing the laboratory component to six laboratories (3rd–7th Semesters) as per the approved program template.

Resolution: After detailed deliberations, the Senate resolved to approve the Four-Year Curriculum (03-08) Semesters for the B.Tech. Program in Mathematics & Computing as per the Course Structure & Syllabus, placed at **Annexure-1 (Page Nos. 9-53)**.

Senate/14/05	Modular Examination Guidelines.

The proposed guidelines for the conduct and evaluation of Modular Courses were placed before the Senate for consideration and approval. These courses are structured as two independent courses offered within a semester, one conducted before the Mid-Semester Examination and the other after it.

Resolution:

After deliberation, the Senate approved the Modular Examination Guidelines, effective from the Spring Semester 2025–26, with the following provisions:

1. Evaluation Structure in each mid semester course / end semester course independently:
   - Teacher's Assessment (TA): 40–60%
   - Single Examination: 60–40% (Mid/ End Semester examination)
2. The chosen weightage and components shall be decided by the course instructor and announced to the students at the beginning of the semester.

Senate/14/06	Ph.D. Fee Structure for Self-Sponsored Candidates

The proposed fee structure for Ph.D. candidates under the Self-Sponsored Category was placed before the Senate for consideration and approval.

The Senate reviewed the existing fee-structure for the Industry sponsored Ph.D. candidates and suggested the following for both categories, as below:

1. The tuition fee for both Industry-Sponsored and Self-Sponsored Ph.D. candidates shall be ₹15,000 per semester.
2. The Gymkhana fee of ₹1,000 per semester shall be applicable to both categories.
3. The other fees for Self-Finance candidates are same as applicable to existing Industry-sponsored candidates.

Resolution: After detailed deliberations, the Senate recommended the revised fee structure for both Industry sponsored and Self-sponsored candidates for pursuing Ph.D., effective from the Spring Semester 2025-26, as placed at **Annexure-2 (Page No. 54)**, for the approval of the F.C./ Board.

Senate/14/07	Admission Criteria for M.Tech. Program

The proposal defining the eligibility criteria and admission categories for the M.Tech. programmes of the Institute was placed before the Senate for consideration. A new Self-Financed Category was introduced in addition to the existing categories - Regular, Sponsored, and Foreign National in the admission category. The corresponding fee structure was also presented for approval.

1. **Regular Category:** Candidates must have a first-class or minimum 60% marks or 6.0 CPI in the eligible qualifying degree. For SC/ST students, a minimum of 55% marks or equivalent CPI is required.

In addition, the applicant must also have a valid GATE score. Stipend will be provided by the Institute based on the candidate fulfilling the eligibility criteria.

2. **Sponsored Category:** Candidates must be employed in industry, academic, or research organizations and shall be required to produce a No Objection Certificate (NOC) from their employer at the time of interview. Candidates must have a first-class or minimum 60% marks or 6.0 CPI in the eligible qualifying degree. For SC/ST students, a minimum of 55% marks or equivalent CPI is required. GATE score is not required for admission. Candidate selected under this category are not eligible for any stipend from the Institute.

3. **Self-Financed Category:** Candidates who are not employed and/or do not possess a valid GATE score may apply under this category. Candidates must have a first- class or minimum 60% marks or 6.0 CPI in the eligible qualifying degree. For SC/ST students, a minimum of 55% marks or equivalent CPI is required Selection will be based on written test, and/or personal interview conducted by the concerned department. Candidate selected under this category are not eligible for any stipend from the Institute.

4. **Foreign National Category:** Admission of candidates from ICCR/SAR countries and non-SAR countries shall be governed by the approved international admission norms and corresponding fee structures, not eligible for any stipend from the Institute. Selection will be based on academic performance, written test, and/or personal interview conducted by the concerned department. Candidate selected under this category are not eligible for any stipend from the Institute.

Resolution:

After detailed deliberation, the Senate recommended the following for approval of the FC/ Board:

(i) The admission framework for M.Tech. programmes under the categories Regular, Sponsored, Self-Financed and Foreign National as mentioned above, along with the respective eligibility criteria, to be effective from the Academic Year 2026–27.

(ii) The fee structure for self-financed category for implementation from the academic year 2026-27, as placed at **Annexure-3 (Page No. 55)**.

(iii) With regard to the criteria for stipend eligibility under the Regular category, the Senate recommended that a limited number of Institute Fellowships/Stipends may be awarded to meritorious candidates based on their GATE rank/ score, subject to verification.

However, the Senate advised that the number of Fellowships/ Stipends and the *specific eligibility cut-off (rank or percentile)* be further examined and finalized in consultation with the Finance Committee and Board respectively for ensuing the feasibility.

Senate/14/08	NOC Format for M.Tech. Students.

The format for *No Objection Certificate (NOC)* for sponsored M.Tech. candidates, to be issued by the concerned employer organisation, was placed before the Senate for approval.

Resolution: The Senate resolved to approve the NOC format, placed at **Annexure-4 (Page No. 56).**

Senate/14/09	Revision of Syllabus for UG B.Tech. in Mechanical Engineering.

The proposed revisions in the syllabus of the following courses of B.Tech. program in Mechanical Engineering, were placed before the Senate for consideration and approval:

1. Mechanical Engineering Lab–II
2. Strength of Materials
3. Nanotribology and Nanomechanics: Fundamentals and Applications (Elective)
4. Dynamics of Machines

Resolution:

After detailed deliberation, the Senate approved the revised syllabus for the following courses, as placed at **Annexure–5 (Page Nos. 57 - 60)**:

- Mechanical Engineering Lab – II
- Nanotribology and Nanomechanics: Fundamentals and Applications (Elective)

However, the proposed revisions to the syllabus for the following courses were not approved by the Senate.

- Strength of Materials, and
- Dynamics of Machines

Senate/14/10	Proposal for Introduction of M.Tech. Program in Chemical Engineering.

The proposal for introduction of a new M.Tech. program in Chemical Engineering, from the Academic Year 2026–27 was placed before the Senate for consideration. The proposed program is as per the Institute's approved M.Tech. template, including core courses, laboratories, electives, and thesis work.

The detailed Course structure and curriculum was placed at **Annexure–6 (Page Nos. 61-93)**.

Resolution: The Senate resolved to recommend the proposal for the introduction of the M.Tech. program in Chemical Engineering along with the Course Structure and Curriculum, from the Academic Year 2026–27 with an intake of 22 students initially, for the approval of the Board.

Senate/14/11	Courses proposed for Ph.D. Program.

The Senate was apprised that the Chairman, Senate approved the following new courses for inclusion in the Ph.D. Program:

- Advanced Fluid Mechanics
- Optimization Techniques
- Engineering Geology
- Introduction to Petroleum Engineering.

The detailed syllabus of the above said courses was placed before the Senate. The Senate was requested to ratify the decision taken by the Chairman Senate.

Resolution: The Senate reviewed the syllabus of the above new courses for inclusion in the Ph.D. program and ratified the decision taken by the Chairman, Senate.

Senate/14/12	Inclusion of Co-supervisor for a sponsored Ph.D. Candidate.

The Senate was apprised that the Chairman, Senate accorded the approval for the inclusion of Prof. T. Hemant Kumar as Co-supervisor for Mr. Venkat Krishna Kumar Valangati, a Sponsored Ph.D. candidate under the supervision of Prof. Geetanjali Chauhan.

The Senate was requested to ratify the decision taken by the Chairman, Senate.

Resolution: The Senate ratified the action taken by the Chairman, Senate.

Senate/14/13 (i)	Any other item with the permission of the Chair.

The Senate was apprised that the Chairman, Senate, had approved the extensions of dates for conducting Ph.D. seminars, based on the recommendations of the respective supervisors, as detailed below:

- Ms. S. Hemalatha, Ph.D. Scholar (Date of Admission: 17.07.2023), under the supervision of Prof. A. Seshagiri Rao – *Extension of the date for the Enhancement Seminar up to 24.12.2025.*
- Mr. V. Sri Harsha, Ph.D. Scholar, under the supervision of Prof. Nilanjan Pal – *Extension of the date for the Registration Seminar (Comprehensive Examination completed on 09.12.2024).*
- Ms. A. Ramasathi, Ph.D. Scholar, under the supervision of Prof. Sivasankar P. – *Extension of the date for the Registration Seminar up to 29.09.2025 (Date of Comprehensive Examination: 09.12.2024).*

Resolution:

The Senate ratified the action taken by the Chairman, Senate, in approving the extensions of dates for conducting the above Ph.D. seminars.

Senate/14/13 (ii)	**Approval of the newly added expert members for the Faculty Selection Committee at IIPE**

The Senate was apprised that the Chairman Senate approved the list of Expert Members for considering in the panel whilst constituting the Faculty Selection Committee at IIPE, for the respective Departments, as placed at **Annexure-7**.

The Senate was requested to ratify the decision taken by the Chairman, Senate.

Resolution: The Senate ratified the action taken by the Chairman, Senate.

The meeting ended with thanks to the Chair.

Submitted for kind approval please.

30.11.2025

(R.P. Dwivedi)
Registrar &
Secretary, Senate, IIPE

Approved
01/12/25

(Prof. Shalivahan)
Director &
Chairman, Senate, IIPE

Indian Institute of Petroleum and Energy, Visakahpatnam

14th Senate Meeting (27-10-2025)

Sl No.	Chairperon		Signature
1	Prof. Shalivahan, Director and Chairperson, Senate		Attended offline
Sl No.	**External Members**	**Organization**	
2	Prof. Arvind Kumar Mishra	Director , CSIR - CIMFR Dhanbad	Attended virtually
3	Prof. K Srinivas Reddy	Professor, IIT Madras	Attended virtually
4	Shri Binayananda Bharali	Executive Director, OIL	Attended virtually
Sl No.	**Deans and Assoc. Deans (Ex-Officio Members)**	**Section**	
5	Prof. K Vijaya Kumar	Dean (Research & Development)	Attended virtually
6	Prof. A Seshagiri Rao	Assoc. Dean (Faculty Affairs)	Attended virtually
7	Prof. Himangshu Kakati	Assoc. Dean (Academic Affairs), HoD (PE&ES)	
8	Prof. CV Rao	Assoc. Dean (Students' Affairs)	Attended virtually
9	Prof. P Aparoy	Assoc. Dean (Research & Development)	Attended virtually
10	Prof. Sivasankar	Assoc. Dean (Planning)	Attended virtually
11	Prof. Rajat Jain	Assoc. Dean (International Relations and Alumni Affairs)	
12	Prof. Ranjan Pramanik	Assoc. Dean (Innovation, Incubation and Entrepreneurship)	Leave of Absence
Sl No.	**Head of the Department (Ex-Officio Members)**	**Department**	
13	Prof. P Venkata Reddy	Chemical Engineering	Attended virtually
14	Prof. Arun Kumar Pujari	Mechanical Engineering	
15	Prof. Somnath Ghosh	Humanities & Sciences	
Sl No.	**Faculty (Members)**	**Department**	
16	Prof. R Ramunaidu	Humanities & Sciences	Attended virtually
17	Prof. T Hemanth Kumar	Chemical Engineering	Leave of Absence
18	Prof. Raka Mondal	Chemical Engineering	Leave of Absence
19	Prof. Dipankar Pal	Chemical Engineering	Attended virtually
Sl No.	**Registrar** (As Ex-officio Secretary)	**Section**	
20	Shri Ramphal Dwivedi	Administration	27.10.2025

14th Meeting of the Senate - IIPE usage report

Invited: 1 Registered: N/A Attended: 19

App participant list (19)

Name	Email	Date	Invited	Registered	Duration	Audio types
Dr. Venkata Reddy	06e918c3-9eb7-4c64-8705-c7f880f3d3d1@guest.webex.localhost	Oct 27,2025	No	No	69 mins	VoIP
k S Reddy	869bddc5-4e75-4074-bbf9-4a33e29ed87d@guest.webex.localhost	Oct 27,2025	No	No	20 mins	VoIP
Dr C V Rao	cvrao1972.cse@iipe.ac.in	Oct 27,2025	No	No	3 mins	VoIP
k S Reddy	1434c4fa-2785-41fb-b6b4-6b7169f2cc9d@guest.webex.localhost	Oct 27,2025	No	No	31 mins	VoIP
Vijay IIPE	d3a51dc0-94b7-45c2-9be5-681d1283f287@guest.webex.localhost	Oct 27,2025	No	No	62 mins	VoIP
Dr. Venkata Reddy P	venkat_palleti.che@iipe.ac.in	Oct 27,2025	No	No	64 mins	VoIP
PROF ARVIND KUMAR MISHRA	20f6b263-d2be-4794-ad43-a6cd9f0f3fcd@guest.webex.localhost	Oct 27,2025	No	No	62 mins	VoIP
Sivasankar	sivasankar.petro@iipe.ac.in	Oct 27,2025	No	No	67 mins	VoIP

14th Meeting of the Senate - IIPE usage report

Invited: 1 Registered: N/A Attended: 19

App participant list (19)

Name	Email	Date	Invited	Registered	Duration	Audio types
Dr. Ramunaidu Randhi	0d48e3c8-a07c-4323-b8b0-ed34ee2dd577@guest.webex.localhost	Oct 27,2025	No	No	65 mins	VoIP
Aparoy	5c06ff37-b406-4065-9a0c-bdcc3dcffb52@guest.webex.localhost	Oct 27,2025	No	No	77 mins	VoIP
Helpdesk IT	helpdesk@iipe.ac.in	Oct 27,2025	No	No	138 mins	VoIP
k S Reddy	95fe746b-b673-4f35-8599-e28cd6c3f777@guest.webex.localhost	Oct 27,2025	No	No	4 mins	VoIP
Dr. Venkata Reddy	5ce89fd3-cb08-4ec0-9c37-030d567c0ad1@guest.webex.localhost	Oct 27,2025	No	No	1 min	VoIP
Dr C V Rao	cvrao1972.cse@iipe.ac.in	Oct 27,2025	No	No	41 mins	VoIP
B Bharali, Oil India Ltd.	dbebaf8b-3af1-4641-a9b6-96e54ff6e1a9@guest.webex.localhost	Oct 27,2025	No	No	38 mins	VoIP
Dipankar Pal	dipankar.che@iipe.ac.in	Oct 27,2025	No	No	52 mins	VoIP

14th Meeting of the Senate - IIPE usage report

Invited: 1 Registered: N/A Attended: 19

App participant list (19)

Name	Email	Date	Invited	Registered	Duration	Audio types
Dipankar Pal	dipankar.che@iipe.ac.in	Oct 27,2025	No	No	2 mins	VoIP
Dipankar Pal	dipankar.che@iipe.ac.in	Oct 27,2025	No	No	15 mins	VoIP
Seshagiri Rao Ambati	f3f06ae2-bb26-4785-abec-7c3998a0c267@guest.webex.localhost	Oct 27,2025	No	No	66 mins	VoIP

30.11.2025

Annexure-1

COURSE STRUCTURE and SYLLABUS

for

4 Year B. Tech. in Mathematics & Computing

Indian Institute of Petroleum and Energy

Visakhapatnam, Andhra Pradesh – 530003

Agenda: Proposal to start B. Tech in Mathematics & Computing at IIPE, Visakhapatnam.

Overview:

In recent years, there have been several ground-breaking mathematical developments that have far reaching implications on our daily lives. These developments range from mathematical modelling to large scale optimization, solving PDEs via data-driven strategies to mimicking neural processing in human brains, to name but a few. With vast potential for applications, these fundamental topics, not surprisingly, have become cynosure for researchers from several scientific fields while resulting in products like Chat GPT, high precision imaging in medical domain, physics-aware neural processing etc. At the heart of these developments lie some deep rooted advanced mathematical, computational, and data analytic tools, which form the foundational pillars of emerging fields like Artificial Intelligence (AI), Machine Learning (ML), Deep Learning, and Data Science (DS).

Having found the need for trained man power who can grab opportunities by making a foray into these fields, several IITs, NITs and IIITs have of late started offering such programmes as B. Tech/M. Tech/ Integrated M. Sc/ M. Tech with specialization being Mathematics as applied in AI/ML/DS. Intending not to be left behind and being aware of growing importance of these fields, the IIPE at Visakhapatnam proposes to introduce a 4-year B. Tech. programme in Mathematics and Computing with emphasis on AI and ML. This visionary program is envisaged to attract the nation's brightest minds through JEE Advanced examination and offer a formidable combination of Mathematics and Computer Science. It is expected that the programme will concentrate on areas where Mathematics and Computing are most relevant and inter-laced. The curriculum has been designed in such a way that this programme provides a perfect platform for those who seek strong Mathematical and Analytical components with specialization in topics like AI/ML/DS/Energy.

To summarize, the program aims to produce future leaders who will be at the forefront of research, development, and innovation in futuristic disciplines and next generation technologies that require deep use of Mathematics, Computer Science and Data Science.

Intake of the students for this programme in upcoming academic year 2024-25 is as follows:

S. No	UG programme	Duration	Total intake
1.	B. Tech. Mathematics & Computing	4 Years	22*

* Reservation policy will be applicable as per the GoI norms.

1. **Admission to the Programme:**
   a. The admission to B. Tech. Programmes shall be made once in a year normally in July through Joint Entrance Examination (JEE) Advanced Ranking, conducted on an All India Level / Basis by IITs.
   b. The candidates, seeking admission in B. Tech. programmes, shall fulfil the following criteria in addition to the rank in the merit list of Joint Entrance Examination (JEE) Advanced of the respective year. Candidates should have passed intermediate (10+2 (PCM)) with Science Subjects or equivalent examination with minimum 75% marks in aggregate (65% marks in case of students SC/ST/PWD categories).

Degree Requirements:

The degree requirements for undergraduates are specified in terms of

(a) Minimum total credits to be earned: As per the UG manual of IIPE, these will be fixed by each department and will generally be between 165 and 180.

The summary of percentage credits for this programme is as follows.

S. No	Course Type	No. of credits	Percentage of credit
1	Institute core (IC)	66	~40
2	Departmental Core (DC)	70	~42
3	Departmental Elective (DE)	12	~8
4	Open Elective (OE)	17	~10
	Total	165	

(b) These requirements make the programme flexible, as the students can choose courses depending on their varying interests, as long as they satisfy the minimum requirement.

All the rules and regulations of the programme will be followed as per the institute UG programme guidelines.

SEMESTER - I							
Sl. No	**Code**	**Course Name**	**Course type**	**L**	**T**	**P**	**Credit**
1	IC1101	Calculus	IC	3	1	0	4
2	IC1102	General Chemistry	IC	3	1	0	4
3	IC1103	Engineering Mechanics	IC	3	1	0	4
4	IC1104	Introduction to Materials	IC	3	0	0	3
5	IC1105	Engineering Graphics	IC	1	0	3	3
6	IC1106	English for Communication	IC+HSS	1	0	2	2
7	IC1107	Electrical Technology	IC (Modular)	2	0	0	2
8	IC1108	Basic Electronics		2	0	0	2
9	IC1109	Chemistry Lab	IC	0	0	3	3
10		EAA I		0	0	0	P/F
Total				**18**	**3**	**8**	**27**

SEMESTER - II							
Sl. No	**Code**	**Course Name**	**Course type**	**L**	**T**	**P**	**Credit**
1	IC1201	Linear Algebra & Differential Equations	IC	3	1	0	4
2	IC1202	Strength of Materials	IC	3	1	0	4
3	IC1203	Physics	IC	3	1	0	4
4	IC1204	Programming and Data structures	IC	3	0	3	5
5	IC1205	Earth Energy & Environment	IC (Modular)	2	0	0	2
6	IC1206	Fundamentals of Biological Systems		2	0	0	2
7	IC1207	Electrical & Electronics Lab	IC	0	0	3	2
8	IC1208	Workshop	IC	0	0	3	2
9		EAA II		0	0	0	P/F
Total				**16**	**3**	**9**	**25**

SEMESTER - III							
Sl. No	**Code**	**Course Name**	**Course type**	**L**	**T**	**P**	**Credit**
1	IC2101	Numerical Methods & Transform calculus	IC	4	0	0	4
2	IC2102	Object Oriented Programming	IC	2	0	3	4
3	MC2101	Discrete Mathematics	DC	3	0	0	3
4	MC2102	Real & Complex Analysis	DC	3	1	0	4
5	MC2103	Advanced Data Structures and Algorithms	DC	3	0	0	3
6	MC2104	Advanced Data Structures and Algorithms Lab	DP	0	0	3	2
7	EA2101	EAA III		0	0	0	P/F
Total				**15**	**1**	**6**	**20**

SEMESTER - IV							
Sl. No	**Code**	**Course Name**	**Course type**	**L**	**T**	**P**	**Credit**
1	MC2201	Design and Analysis of Algorithms	DC	3	0	0	3
2	MC2202	Introduction to Probability & Statistics	DC	3	0	0	3
3	MC2203	Advanced Linear Algebra & Applications	DC	3	0	0	3
4	MC2204	Optimization Methods and Applications	DC	3	0	0	3
5	MC2205	Operating Systems	DC	3	0	0	3
6	MC2206	Operating Systems Lab	DP	0	0	3	2
7	MC2207	Mobile application development with Java	DP	0	0	3	2
8	EA2201	EAA IV		0	0	0	P/F
Total				**15**	**0**	**6**	**19**

SEMESTER - V							
Sl. No	**Code**	**Course Name**	**Course type**	**L**	**T**	**P**	**Credit**
1	MC3101	Graph Theory	DC	3	0	0	3
2	MC3102	Theory of Computation	DC	3	0	0	3
3	MC3103	Machine Learning & Applications	DC	3	0	0	3
3	MC3104	Machine Learning & Applications Lab	DP	0	0	3	2
4	MC3105	Database Management Systems	DC	3	0	0	3
5	MC3106	Database Management Systems Lab	DP	0	0	3	2
6		Elective-I	DE	3	0	0	3
Total				**15**	**0**	**6**	**19**

SEMESTER - VI							
Sl. No	**Code**	**Course Name**	**Course type**	**L**	**T**	**P**	**Credit**
1	MC3201	Computer Networks	DC	3	0	0	3
2		Deep Learning & Applications	OE	3	0	3	5
3	MC3202	Web Technologies	DC	3	0	0	3
4	MC3203	Web Technologies Lab	DP	0	0	3	2
5		Elective-I	DE	3	0	0	3
6	MC3204	Project-1	PR1	0	0	3	2

Total		12	0	9	18

SEMESTER - VII							
Sl. No	**Code**	**Course Name**	**Course type**	**L**	**T**	**P**	**Credit**
1	MC4101	Project-2	PR2	0	0	3	2
2	MC4102	Applied Natural Language Processing	DC	3	0	0	3
3		Industrial psychology & Professional Ethics	IC+HSS	2	0	0	2
		Economics	IC+HSS	2	0	0	2
4		Industrial Training	IC	0	0	0	2
5		Elective-I	DE	3	0	0	3
6		Elective-II	DE	3	0	0	3
7		Elective-II	OE	3	0	0	3
Total				**16**	**0**	**3**	**20**

	SEMESTER - VIII						
Sl. No	**Code**	**Course Name**	**Course type**	**L**	**T**	**P**	**Credit**
1	MC4201	Project-3	PR3	0	0	9	6
2		Elective I	OE	3	0	0	3
3		Elective II	OE	3	0	0	3
4		Elective III	OE	3	0	0	3
5		Comprehensive Viva-Voce		0	0	2	2
Total				**9**	**0**	**11**	**17**
CUMULATIVE TOTAL				**116**	**7**	**58**	**165**

ELECTIVES						
Sl. No	**Code**	**Course Name**	**L**	**T**	**P**	**Credit**
1		Mathematical foundations of AI	3	0	0	3
2		Multivariate Calculus & Measure Theory	3	0	0	3
3		Convex Optimization	3	0	0	3
4		Computational Methods for Differential Equations	3	0	0	3
5		Functional Analysis	3	0	0	3
6		Computational Number Theory	3	0	0	3
7		Stochastic Models	3	0	0	3
8		High-Performance Computing	3	0	3	6
9		Mathematical Modelling and Numerical Simulation	3	0	0	3
10		Financial Mathematics	3	0	0	3
11		Image Processing	3	0	0	3
12		Mathematical Image Processing	3	0	0	3
13		Statistical Simulation & Data Analysis	3	0	0	3
14		Computational Biology	3	0	0	3
15		Applied Functional Analysis	3	0	0	3
16		Compressed Sensing	3	0	0	3
17		Numerical Linear Algebra	3	0	0	3
18		Numerical Methods for Hyperbolic Problems	3	0	0	3
19		Operational Research	3	0	0	3
20		Signals & Systems	3	0	0	3
21		Time Series Analysis	3	0	0	3
22		Numerical Linear Algebra	3	0	0	3
23		Stochastic Processes	3	0	0	3
24		Bioinformatics	3	0	0	3
25		Probability & Computing	3	0	0	3
26		Combinatorial optimization	3	0	0	3
27		Partial Differential Equations	3	0	0	3
28		Pattern Recognition	3	0	0	3
29		Big Data Analytics	3	0	0	3
30		Numerical Analysis	3	0	0	3
31		Graph Neural Networks	3	0	0	3
32		Abstract Algebra	3	0	0	3
33		Statistical Learning: Theory and Applications	3	0	0	3
34		Quantum Computing	3	0	0	3

Semester - III						
Course Type	**Code**	**Name of Course**	**L**	**T**	**P**	**Credit**
DC	MC2101	***Discrete Mathematics***	3	0	0	3

Syllabus

Sets and propositions: Combinations of sets, Finite and Infinite sets, Uncountably infinite sets, Principle of inclusion and exclusion, Mathematical induction. Propositions, Fundamentals of logic, First order logic, Ordered sets.

Permutations, Combinations, Numeric functions, Generating functions.

Recurrence relations and recursive algorithms: Recurrence relations, Linear recurrence relations with constant coefficients, Solution by the method of generating functions, Sorting algorithm.

Relations and functions: Properties of binary relations, Equivalence relations and partitions, Partial and total ordering relations, Transitive closure and Warshal's algorithm.

Boolean algebra : Chains, Lattices and algebraic systems, Principle of duality, Basic properties of algebraic systems, Distributive and complemented lattices, Boolean lattices and algebras, Uniqueness of finite Boolean algebras, Boolean expressions and functions.

Graphs and planar graphs : Basic terminology, Multigraphs and weighted graphs, Paths and circuits, Shortest paths in weighted graphs, Eulerian paths and circuits, Hamiltonian paths and circuits. Colorable graphs, Chromatic numbers, Five-color theorem and Four color problem.

Trees and cut-sets : trees, rooted trees, Path lengths in rooted trees, Spanning trees and BFS & DFS algorithms, Minimum spanning trees and Prims &Kruskal's algorithms.

Text Books/ Reference:

1. C.L.Liu: Elements of Discrete Mathematics, McGraw Hill, 1985.
2. J.P. Tremblay and R Manohar : Discrete Mathematical Structures with applications to Computer Science, McGraw Hill Book Co., New Delhi 1975.
3. J. L. Mott, A. Kandel and T. P. Baker : Discrete Mathematics for Computer Scientists,Reston Pub. Co, 1983.
4. K.D. Joshi: Foundations in Discrete Mathematics, New Age International, 1989.

33		Cloud Computing	3	0	0	3
34		Reinforcement Learning	3	0	0	3

Course Type	Code	Name of Course	L	T	P	Credit
DC	MC2102	***Real & Complex Analysis***	3	1	0	4

Syllabus

Real Analysis: Metric spaces: definition and examples. Open, closed and bounded sets. Interior, closure and boundary. Convergence and completeness. Continuity and uniform continuity. Connectedness, compactness and separability. Heine-Borel theorem. Pointwise and uniform convergence of real-valued functions. Equicontinuity. Ascoli-Arzela theorem.

Complex Analysis: Limits, continuity and differentiability of functions of a complex variable. Analytic functions and the Cauchy-Rieman equations. Definition of contour integrals, Cauchy's integral formula and derivatives of analytic functions. Morera's and Liouville's theorems. Maximum Modulus principle. Taylor and Laurent series. Isolated singular points and residues. Cauchy's Residue theorem and applications.

Text Books/ Reference:

1. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, Paperback Edition, 2017.
2. Walter Rudin, Principles of Mathematical Analysis, McGraw Hill, Third Paperback Edition, 2017.
3. S. Kumaresan, Topology of Metric Spaces, Narosa, Second Edition, 2005.
4. Robert Magnus, Metric Spaces: A Companion to Analysis, Springer Undergraduate Mathematics Series, 2011.

Course Type	Code	Name of Course	L	T	P	Credit
DC	MC2103	***Advanced Data Structures and Algorithms***	3	0	0	3

Syllabus

Dictionaries : Sets, Dictionaries, Hash Tables, Open Hashing, Closed Hashing (Rehashing Methods), Hashing Functions(Division Method, Multiplication Method, Universal Hashing), Analysis of Closed Hashing Result (Unsuccessful Search, Insertion, Successful Search, Deletion), Hash Table Restructuring, Skip Lists, Analysis of Skip Lists.

ADT Binary Trees: Tree representation, traversal, application of binary trees in Huffman coding. Introduction to expression trees: traversal vs post/pre/infix notation. Recursive traversal and other tree parameters (depth, height, number of nodes etc.)

Balanced Trees : AVL Trees: Maximum Height of an AVL Tree, Insertions and Deletions. 2-3 Trees : Insertion, Deletion.

Priority Queues :
Binary Heaps : Implementation of Insert and Delete min, Creating Heap.
Binomial Queues : Binomial Queue Operations, Binomial Amortized Analysis, Lazy Binomial Queues

Graphs : Operations on Graphs: Vertex insertion, vertex deletion, find vertex, edge addition, edge deletion, Graph Traversals- Depth First Search and Breadth First Search(Non recursive) . Graph storage Representation- Adjacency matrix, adjacency lists.

Graph algorithms : Minimum-Cost Spanning Trees- Prim's Algorithm, Kruskal's Algorithm Shortest Path Algorithms: Dijkstra's Algorithm, All Pairs Shortest Paths Problem: Floyd's Algorithm, Warshall's Algorithm,

Sorting Methods : Order Statistics: Lower Bound on Complexity for Sorting Methods: Lower Bound on Worst Case Complexity, Lower Bound on Average Case Complexity, Heap Sort, Quick Sort, Radix Sorting, Merge Sort.

Pattern matching and Tries : Pattern matching algorithms- the Boyer –Moore algorithm, the Knuth-Morris-Pratt algorithm
Tries: Definitions and concepts of digital search tree, Binary tries, Patricia , Multi-way tries.

Text Books/ Reference:

1. Data Structures and Algorithm Analysis in C++, by Mark Allen Weiss (Pearson 2007).
2. Data structures and Algorithms in C++ -- by Adam Drozdek (1994 2001).
3. How to solve it by Computer -- by R G Dromey (PHI 1982, Paperback 2008).
4. Fundamental of Data Structures in C – by Horowitz, Sahni and Anderson-Freed (Silicon Press 2007).
5. Data Structure Using C and C++ -- by Y. Langsam, M. J. Augenstein and A. N. Tanenbaum (Pearson Education, 2nd Edition, 2015).

Course Type	Code	Name of Course	L	T	P	Credit
DP	MC2104	***Advanced Data Structures and Algorithms Lab***	0	0	3	2

Syllabus

Lab Experiments:

1. Implement Dictionary functionality using the Hashing methods: division method, Multiplication method, Universal hashing
2. Implement AVL tree operations
3. Implement 2-3 trees.
4. Implement binary heap.
5. Implement graph operations (insert/delete vetex/edge)
6. Implement graph DFS/BFS nonrecursive traversals
7. Implement the Graph algorithms: Prim's, Krushkal's algorithms
8. Implement Dijkstra's algorithm to find the shortest path in a graph.
9. Implement pattern matching algorithms Boyer-Moore and Knuth-Morris-Pratt

Text Books/ Reference:

1. Data Structures and Algorithm Analysis in C++, by Mark Allen Weiss (Pearson 2007).
2. Data structures and Algorithms in C++ -- by Adam Drozdek (1994 2001).
3. How to solve it by Computer -- by R G Dromey (PHI 1982, Paperback 2008).
4. Fundamental of Data Structures in C – by Horowitz, Sahni and Anderson-Freed (Silicon Press 2007).
5. Data Structure Using C and C++ -- by Y. Langsam, M. J. Augenstein and A. N. Tanenbaum (Pearson Education, 2nd Edition, 2015).

Semester - IV						
Course Type	**Code**	**Name of Course**	**L**	**T**	**P**	**Credit**
DC	MC2201	***Design and Analysis of Algorithms***	3	0	0	3

Syllabus

Introduction: Problem-solving -- adding 2 n-bit numbers, multiplication as repeated addition. Running time analysis -- recall of asymptotic notation, big-oh, theta, big-omega, and introduce little-oh and little-omega. Worst case and average case complexity.

Basic paradigms with illustrative examples -- incremental design (e.g., incremental sorting, interpolating polynomials), decremental design (e.g., GCD with discussion on input size, factorial), and pruning (e.g., order statistics). Divide and Conquer: Integer multiplication revisited with an efficient algorithm that motivates and leads into recurrences. Solving recurrences using recurrence trees, repeated substitution, statement of master theorem. Brief recall of merge sort and its recurrence. Median in worst case linear time.

Application of Graph Traversal Techniques: Recall representation of graphs, BFS (as a method for SSSP on unweighted graphs), DFS, connected components, topological sorting of DAGs, biconnected components, and strongly connected components in directed graphs.

Greedy Algorithms: Greedy choice, optimal substructure property, minimum spanning trees -- Prims and Kruskals, Dijkstra s shortest path using arrays and heaps, fractional knapsack, and Huffman coding (use of priority queue).

Dynamic Programming: Integral knapsack (contrasted with the fractional variant), longest increasing subsequence, edit distance, matrix chain multiplication, and independent sets in trees.

String Matching: Boyer Moore algorithm.

NP-completeness: reduction amongst problems, classes NP, P, NP-complete, and polynomial time reductions

Text Books/ Reference:

1. Introduction to Algorithms, by Cormen, Leiserson, Rivest, and Stein, MIT Press, Third Edition, 2009.
2. Algorithms, by Dasgupta, Papadimitrou and Vazirani, McGraw-Hill Education, 2006.
3. Computer Algorithms, by Horowitz, Sahni, and Rajasekaran, Silicon Press, 2007.
4. Algorithm Design, by Kleinberg and Tardos, Pearson, 2005.
5. Algorithm Design, by Goodrich and Tamassia, Wiley, 2001.

Course Type	Code	Name of Course	L	T	P	Credit
DC	MC2202	***Introduction to Probability & Statistics***	3	0	0	3

Syllabus

Probability: The axioms of probability, conditional probability, independence, Bayes' rule, Random variables: Discrete, and continuous random variables, cumulative distribution, probability mass and probability density functions, Bernoulli, Binomial, Geometric, Poisson, Uniform, Exponential, Normal and Gamma distributions.

Functions of random variables, expectation, variance, moments, jointly distributed random variables and joint cumulative probability distribution functions, jointly continuous random variables, independent random variables, covariance, sum of random variables.

Statistics: Sampling distributions: Chi-square, t and F distributions, random sample, sample mean and sample variance, the central limit theorem, distributions of the sample mean and the sample variance for a normal population,

Estimation: Unbiasedness, consistency, the method of moments and the method of maximum likelihood estimation, confidence intervals for parameters in one sample and two sample problems of normal populations, confidence intervals for properties, problems

Testing of Hypotheses: Null and alternative hypotheses, the critical and acceptance regions, two types of errors, power of the test, the most powerful test and Neyman-Pearson fundamental lemma, tests for one sample and two sample problems for normal population (t, F, Z tests), tests for proportions, Chi-square goodness of fit test and its applications, problems.

Text Books/ Reference:

1. Sheldon Ross, A first course in probability, Pearson publisher.
2. Sheldon M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, Elsevier.
3. J. S. Milton & J. C. Arnold, Introduction to Probability and Statistics, McGraw Hill.
4. W. Feller, An introduction to Probability theory and its applications
5. Alexander Mood, Franklin Graybill D. Boes, Introduction to the theory of Statistics, McGraw Hill

Course Type	Code	Name of Course	L	T	P	Credit
DC	MC2203	***Advanced Linear Algebra & Applications***	3	0	0	3

Syllabus

Introduce Fields: fields of numbers, finite fields. Review basis and dimension of a vector space, linear transformations, eigenvalue and eigenvector of an operator. LU Factorization. Some applications give rise to Linear Systems Problems Dual and double dual of a vector space and transpose of a linear transformation. Diagonalizability of linear operators of finite dimensional vector spaces, simultaneous triangulation and simultaneous diagonalization. The primary decomposition theorem - diagonal and nilpotent parts. Inner product spaces, Gram-Schmidt orthogonalization, best approximation of a vector by a vector belonging to a given subspace and application to least square problems. Adjoint of an operator, Hermitian, unitary and normal operators. Singular Value Decomposition and its applications. Spectral decomposition. Introduction of bilinear and quadratic forms.

Text Books/ Reference:

1. S. Axler, Linear Algebra Done Right, 2nd edition, Springer-Verlag, 1997.
2. K. Hoffman and R. Kunze, Linear Algebra, Pearson Education India, 2003.
3. G. Strang, Linear Algebra and its Applications.

Course Type	Code	Name of Course	L	T	P	Credit
DC	MC2204	***Optimization Methods and Applications***	3	0	0	3

Syllabus

Linear programming - formulation through examples from engineering/business decision making problems, preliminary theory and geometry of linear programs, basic feasible solution, simplex method, variants of simplex method. Duality and its principles, interpretation of dual variables, dual simplex method. Linear integer programming, applications in real decision-making problems, methods to solve linear integer programs, transportation problems: theory and methodology, assignment problems. Zerosum matrix games, saddle point, linear programming formulation of matrix games, network optimization problems LPP formulation. Nonlinear programming, Lagrange function, KKT optimality conditions, sufficiency of KKT under convexity of quadratic programming, Wolfe's method, applications of quadratic programs.

Text Books/ Reference:

1. Vasek Chvatal, Linear programming, W. H. Freeman publishers, 1983.
2. Robert J. Vanderbei, Linear programming: Foundation and Extension, Springer, 2001.
3. S. Chandra, Jayadeva, A. Mehra, Numerical optimization with applications, Narosa, 2009.
4. Hamdy A. Taha, Operations research: An introduction, Pearson Education, 2006.

Course Type	Code	Name of Course	L	T	P	Credit
DC	MC2205	***Operating Systems***	3	0	0	3

Syllabus

Process Management: Scheduling (essential topics: context-switch, unix fork, scheduling algorithms representing fairness, infinite wait, optimal scheduling, priority inversion)

Synchronization Primitives and Problems, Deadlocks (essential topics: Peterson's algorithm, monitors)

Memory Management: Virtual Memory, Demand Paging (essential topics: fragmentation, pinning, Belady's anomaly, thrashing)

File systems; I/O Management (essential topics: DMA, delayed writes, elevator algorithm). Security.

The Lab part shall include experiments that illustrate booting of a system, implementation of process, memory, file and I/O management concepts, preferably using a popular operating system as a case study.

Text Books/ Reference:

1. Operating Systems Concepts, Abraham Silberschatz, Peter B. Galvin and Greg Gagne, Wiley, 2012.
2. The Design of the Unix Operating System: Maurice Bach, Prentice Hall, 1988.
3. References
4. Modern Operating Systems, Andrew S Tanenbaum and Herbert Bos, Fourth Edition, Pearson Education, 2014.
5. Operating Systems: Principles and Practice, Thomas Anderson and Michael Dahlin, Recursive Books, 2014.

Course Type	Code	Name of Course	L	T	P	Credit
DP	MC2206	***Operating Systems Lab***	0	0	3	2

Syllabus

OS Lab:

This is a companion lab to the Operating Systems course. Students implement a tiny operating system that has a (primitive) all the important features like process management (3 weeks), memory management (3 weeks), file systems (3 weeks), and inter-process communication and synchronization (3 weeks).

Text Books/ Reference:

1. Operating Systems Concepts, Abraham Silberschatz, Peter B. Galvin and Greg Gagne, Wiley, 2012.
2. The Design of the Unix Operating System: Maurice Bach, Prentice Hall, 1988.
3. References
4. Modern Operating Systems, Andrew S Tanenbaum and Herbert Bos, Fourth Edition, Pearson Education, 2014.
   Operating Systems: Principles and Practice, Thomas Anderson and Michael Dahlin, Recursive Books, 2014.

Course Type	Code	Name of Course	L	T	P	Credit
DP	MC2207	***Mobile application development with Java***	0	0	3	2

Syllabus

LIST OF LAB EXPERIMENTS:

Get familiar with GUI components, Fonts, colors, layout managers, and event listeners,
and build a calculator application. Develop an application that draws basic graphical primitives on the screen.
Develop an application that makes use of a database.
Develop an application that makes use of RSS Feed.
Implement an application that implements Multithreading.
Develop a native application that uses GPS location information.
Implement an application that writes data to the SD card.
Implement an application that creates an alert upon receiving a message.
Write a mobile application that creates an alarm clock.

Text Books/ Reference:

1. Android programming: the big nerd ranch guide. by Bill Phillips, Chris Stewart, and Kristin Marsicano
2. Head First Android Development: A Brain-Friendly Guide" by Dawn Griffiths and David Griffiths
3. Professional Android 4 application development. John Wiley & Sons.
4. Mobile applications: architecture, design, and development. Meier, R; Prentice Hall PTR.

Semester - V						
Course Type	**Code**	**Name of Course**	**L**	**T**	**P**	**Credit**
DC	MC3101	***Graph Theory***	3	0	0	3

Syllabus

Introduction to Graphs: Definition and basic concepts; Trees: characterizations, counting of minimum spanning tree; Paths and Distance in Graphs: Basic Definitions, center and median of a graph, activity digraph and critical path; Eulerian Graphs: Definition and Characterization; Hamiltonian Graphs: Necessary and sufficient conditions, Planar Graphs: properties, dual, genus of a graph; Graph Coloring: vertex coloring, chromatic polynomials, edge coloring, planar graph coloring; Matching and Factorizations: maximum matching in bipartite graphs, maximum matching in general graphs, Hall's marriage theorem, factorization; Networks: The Max-flow min-cut theorem, connectivity and edge connectivity, Menger's theorem; Graph and Matrices.

Text Books/ Reference:

1. J.A.Bondy and U.S.R.Murty: GraphTheory, Springer,2008.
2. R.Diestel: Graph Theory, Springer(low price edition) 2000.
3. B. Bollob´as, Modern Graph Theory (Graduate Texts in Mathematics 184), 1st ed. Springer-Verlag New York, 1998.

Course Type	Code	Name of Course	L	T	P	Credit
DC	MC3102	*Theory of Computation*	3	0	0	3

Syllabus

Finite Automata: Basic Definition of an automaton, Description of a finite automata, Deterministic finite automata (DFA), Non-deterministic finite automata (NFA), transition systems, Acceptability of a string by a finite automation, The equivalence of DFA and NFA, Construction of minimum automaton. Formal Languages: Basic definitions, Chomsky classification of languages, Languages and their relations, Operations on languages, Languages and automata.

Regular Grammars: Identities and regular expressions, Finite automata and regular expressions, Conversion of non-deterministic systems to deterministic systems, Algebraic method using Arden's theorem, Construction of finite automata equivalent to regular expression, Pumping lemma for regular sets, Applications of pumping lemma. Context-free Grammar: Context-free grammars, Parse trees, Ambiguity in context-free grammars, Simplification of context-free grammars, Normal forms of context-free grammars, Pumping lemma, Decision algorithms. Pushdown Automata: Basic definitions, Acceptance by pushdown automata, Pushdown automata, and context-free languages.

Turing Machines and Linear Bounded Automata (LBA): Turing Machines Model, Representation of a Turing machine, Language acceptability by Turing machines, Design of Turing Machines, Universal Turing Machines and other modifications, Model of linear bounded Automaton, Turing machines and type- 0 Grammars, Linear bounded automata and languages, Halting problem of Turing machines, NP-Completeness. Computability: Introduction and basic concepts, Primitive recursive functions, Recursive functions, Partial recursive functions, and Turing machines.

Text Books/ Reference:

1. J. E. Hopcroft, J. Motwani, and J. D. Ull man, Introduction to Automata Theory, Languages and Computation, Pearson Education, Asia, 2002.
2. J. H. Martin, Introduction of Languages and the Theory of Computation, McGraw-Hill International Edition, New York, 1991.
3. Z. V. I. Kohavi, Switching and Finite Automata Theory, Tata McGraw-Hill, New Delhi, 1972.
4. H. R. Lewis and C. H. Papadimitrou, Elements of the Theory of Computation, Pearson Education.

Course Type	Code	Name of Course	L	T	P	Credit
DC	MC3103	***Machine Learning & Applications***	3	0	3	5

Syllabus

Overview: Machine Learning paradigms; supervised, unsupervised, and reinforcement learning.
Supervised Learning: Bayes classifier, optimality; risk minimization; Generalisation error estimation. Perceptron, logistic regression, least squares, regularization, Kernel methods; SVMs, multilayer Perceptrons, CNNs, and other neural network models. Classifier ensembles, Adaboost algorithm. Unsupervised Learning: Generative models, parameter estimation – Maximum likelihood, Bayesian Methods; latent variables and EM algorithm; graphical models, deep generative models, Principal component Analysis, Independent Component Analysis. Reinforcement Learning and Markov Decision Processes.

Text Books/ Reference:

1. C.M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
2. S Shalev-Shwartz and S. Ben-David, Understanding Machine Learning: From Theory to Algorithms, Cambridge University Press, 2014.
3. Kevin Murphy, Machine learning: A probabilistic perspective, 2012
4. T.Hastie, R.Tibshirani and J.Friedman, The Elements of Statistical Learning: Data Mining, Inference and Prediction', Springer, 2009.
5. A.Zhang, Z.C.Lipton, M.Li, A.J.Smola, Dive into Deep Learning, 2019 (free PDF available)
6. I.Goodfellow, Y.Bengio and A. Courville, Deep Learning, MIT Press, 2016

Course Type	Code	Name of Course	L	T	P	Credit
DC	MC3104	***Database Management Systems***	3	0	0	3

Syllabus

Introduction - General introduction to database systems; Database - DBMS distinction, approaches to building a database, data models, database management system, three-schema architecture of a database, challenges in building a DBMS, various components of a DBMS.

E/R Model - Conceptual data modeling - motivation, entities, entity types, various types of attributes, relationships, relationship types, E/R diagram notation, examples. Relational Data Model - Concept of relations, schema-instance distinction, keys, referential integrity and foreign keys, relational algebra operators: selection, projection, cross product, various types of joins, division, example queries, tuple relation calculus, domain relational calculus, converting the database specification in E/R notation to the relational schema.

SQL - Introduction, data definition in SQL, table, key and foreign key definitions, update behaviors. Querying in SQL - basic select-from-where block and its semantics, nested queries - correlated and uncorrelated, notion of aggregation, aggregation functions group by and having clauses, embedded SQL.

Dependencies and Normal forms - Importance of a good schema design, problems encountered with bad schema designs, motivation for normal forms, dependency theory - functional dependencies, Armstrong's axioms for FD's, closure of a set of FD's, minimal covers, definitions of 1NF, 2NF, 3NF and BCNF, decompositions and desirable properties of them, algorithms for 3NF and BCNF normalization, multi-valued dependencies and 4NF, join dependencies and definition of 5NF.

Data Storage and Indexes - file organizations, primary, secondary index structures, various index structures - hash-based, dynamic hashing techniques, multi-level indexes, B+ trees.

Transaction processing and Error recovery - concepts of transaction processing, ACID properties, concurrency control, locking based protocols for CC, error recovery and logging, undo, redo, undo-redo logging and recovery methods.

No SQL Database – MongoDB

Text Books/ Reference:

1. Database System Concepts (Sixth Edition) Avi Silberschatz, Henry F. Korth, S. Sudarshan McGraw-Hill 2011 ISBN 978-0071325226/ 0-07-352332-1
2. Database Management Systems, Third Edition Raghu Ramakrishnan and Johannes Gehrke McGraw-Hill ©2003 ISBN: 978-0072465631/ 0-07-246563-8
3. Fundamentals of Database Systems, 7th Edition Ramez Elmasri, University of Texas at Arlington Shamkant B. Navathe Pearson India ©2011 ISBN 978-0321369574
4. Database Systems: The Complete Book, (2nd Edition, 2014) Hector Garcia-Molina, Jeffrey D Ullman and Jennifer Widom Pearson India ISBN: 978-9332518674, 9-33-251867-X

Course Type	Code	Name of Course	L	T	P	Credit
DP	MC3105	***Database Management Systems Lab***	0	0	3	2

Syllabus

DBMS Lab:

Objective:

The objective of this lab course is to understand the practical applicability of database management system concepts. Working on existing database systems, designing databases, creating relational databases, and analyzing table design. Writing advanced queries such as relational constraints, joins, set operations, aggregate functions, triggers, views, and embedded SQL. Use ER Diagrams, and UML for related database systems design. The lab course also provides practical knowledge to understand advanced database concepts such as Data mining and Big Data Analysis. Design and implement database applications.

The following or similar assignments can be considered.

Assignment 1.1

1. Consider the following set of requirements for a university database used to maintain student grade reports (transcripts).
A. The university records each student's name, social security number (SSN), address, phone, birthdate, major department, and degree program (B.A., B.S., etc.). An SSN uniquely designates a student.
B. Each department is described by a name, department code, office number, office phone, and college. Name and code values each uniquely characterize a department.
C. Each course has a course name, description, course number, number of credit hours, and offering department. The combination of a course number and an offering department uniquely designates a course.
D. Each section has an instructor, semester, year, course and section number. The section number distinguishes different sections of the same course that are taught during the same quarter and year.
E. A grade report has a student, section, and grade (A,B,C, and D). The combination of a student and section uniquely characterizes a grade report.

Draw the E-R diagram. Create the database in systems like Oracle, MySQL, MSSQL. Compare the features of each of these systems.
Frame and execute the SQL queries for the following:
1. List the names of all students who have registered for courses in more than one department.
2. List the name and SSN of all students who have registered for more than one course in a specified department.
3. List the names of all students who have got at least B grade in all the courses taken by him/her.
4. List the names of all students who have got A's in all the courses offered by the CS department.
5. List the highest grade obtained in each course by students majoring in each of the departments.

Assignment 1.2
Write a C program that connects to the SQL servers using ODBCstandard and prints (formatted) the result of the queries in assignment 1.1.
Repeat this in Java using JDBC.

Assignment 2
Online Book Store
Design a Database System for an online book store (e.g., Amazon), based on the following specifications.

1. Books are represented by, ISBN, Title, Author, Publisher, Edition, Year of Publication, Price, Short Reviews if available, Table of Contents if available, an image of the book cover, category e.g., computer science -> operating systems -> MacOS
2. Customers will use a web-based interface to browse books based on categories and search books using keywords. Initially, only the title and author of the book(s) are displayed; on click, other attributes are displayed. Customers can buy books using their e-purse. The store also displays the number of copies of the book left in stock. Out-of-stock books cannot be purchased immediately but can be ordered.
3. Customers create accounts in the bookstore. Each account contains customer profile information: name, age, geographical location, categories of interest, and email. Each account has an e-purse. Customers can specify the amount of money to be deposited with the e-purse. Profile and e-purse information can be updated by the customer. Customers will log in to the bookstore using an account name and password.
4. All online sales data are recorded in the database with timestamps.
5. The owner of the bookstore can give a requisition for the purchase of books to publishers based on the amount of stock remaining. For each book, the owner maintains a stock which is at least the number of copies of the book sold over the last 3 months. Books ordered by some customers are immediately requisitioned. Requisitions are placed in a requisition table. The publishers inspect the table on the 1st of every month and immediately supply the books. Once a book is supplied, it is cleared from the requisition table.

Design tables for the above system. Create a separate view for customers. Design suitable forms. Implement authorizations. Store the functions and procedures necessary in the database itself. You may also use other languages, besides SQL. The front end may be designed using Java/PHP or any other suitable language.

Text Books/ Reference:

5. Database System Concepts (Sixth Edition) Avi Silberschatz, Henry F. Korth, S. Sudarshan McGraw-Hill 2011 ISBN 978-0071325226/ 0-07-352332-1
6. Database Management Systems, Third Edition Raghu Ramakrishnan and Johannes Gehrke McGraw-Hill ©2003 ISBN: 978-0072465631/ 0-07-246563-8
7. Fundamentals of Database Systems, 7th Edition Ramez Elmasri, University of Texas at Arlington Shamkant B. Navathe Pearson India ©2011 ISBN 978-0321369574
8. Database Systems: The Complete Book, (2nd Edition, 2014) Hector Garcia-Molina, Jeffrey D Ullman and Jennifer Widom Pearson India ISBN: 978-9332518674, 9-33-251867-X

Semester - VI						
Course Type	**Code**	**Name of Course**	**L**	**T**	**P**	**Credit**
DC	MC3201	*Computer Networks*	3	0	0	3

Syllabus

Introduction to Computer Networking Concepts: Layered Network Protocol Architectures; Personal, Local, Metropolitan and Wide Area Networks; Telecommunications and Cellular Networks overview.

Physical Layer: Basics of communications; Physical media types and their important bandwidth and bit-error-rate characteristics; Wired and Wireless media including copper cables, optical fiber and wireless.

Data Link Layer and Logical Link Control (LLC) sub-layer: Framing; Error control including Bit-parity, CRC and Hamming Codes; Reliable transmission and Automatic Repeat Request (ARQ) protocols including Stop-and-Wait, Go-back-N, Selective Repeat. Performance analysis of ARQ protocols. Example protocols such as HDLC and PPP.

Medium Access Control (MAC) sub-layer: Shared media systems; Bus, Star and Ring topologies; TDMA, FDMA, CSMA, CSMA/CD, Ethernet and IEEE 802.3; IEEE 802.11 including CSMA/CA protocols; Performance analysis; Shared and Switched Ethernet; Related protocols such as ICMP, NAT, ARP and RARP.

Network Layer: Internet Protocol (IP) suite; Hierarchical network architectures; IPv4 and IPv6 addressing and headers; Routing protocols including distance-vector and link-state approaches; Interior and Exterior Gateway Protocol concepts; Routing Algorithms including Dijkstra's algorithm and distributed Bellman-Ford algorithm; Example protocols: OSPF, RIP, BGP.

Transport Layer: Reliable end-to-end transmission protocols; UDP header; Details of TCP header and operation including options headers and congestion control; TCP variants such as Reno, Tahoe, Vegas, Compound and CUBIC.

Application Layer: Socket Interface and Socket programming; Example protocols such as DNS, SMTP, FTP, and HTTP. Advanced topics on some of the recent trends in Computer Networks, depending on time availability. Programming assignments based on the theoretical concepts must be part of the course, with 25% weightage towards course grade.

Text Books/ Reference:

1. Andrew S. Tanenbaum, "Computer Networks", Fifth Edition, Pearson Education India, 2013.
2. Kurose and Ross, "Computer Networking - A top-down approach", Seventh Edition, Pearson, 2017.
3. Peterson and Davie, "Computer Networks, A Systems Approach", 5th ed., Elsevier, 2011G. Bachman and L. Narici, Functional Analysis, 2nd Ed., Dover Publication, 1998
4. Ying-Dar Liu, Ren-Hung Hwang, Fred Baker, "Computer Networks: An Open Source Approach", McGraw-Hill, 2011
5. W. Richard Stevens, Bill Fenner and Andrew Rudoff, "Unix Network Programming", Volumes 1 and 2, Third Edition, Addison-Wesley Professional, 2003.
6. Michael Donahoo, Ken Calvert, Pocket Guide to TCP/IP Socket Programming in C, Morgan Kaufmann Series in Networking, 2000.

Course Type	Code	Name of Course	L	T	P	Credit
DC	MC3202	*Web Technologies*	3	0	0	3

Syllabus

Introduction to XHTML: Editing XHTML, First XHTML Example, W3C XHTML Validation Service, Headers, Linking, Images, Special Characters and More Line Breaks, Unordered Lists, Nested and Ordered Lists, Internet and World Wide Web Resources;

Dynamic HTML: Object Model and Collections- Introduction, Object Referencing, Collections all and children, Dynamic Styles, Dynamic Positioning, Using the frames Collection, navigator Object, Summary of the DHTML Object Model; Event Model- vent onclick, Event onload, Error Handling with onerror, Tracking the Mouse with Event onmousemove, Rollovers with onmouseover and onmouseout;

Form Processing- Form Processing with onfocus and onblur, More Form Processing with onsubmit and onreset, Event Bubbling, More DHTML Events; Filters and transitions; Data binding with tabular data control, Structured graphics and active X control;

JavaScript: Functions; Program Modules in JavaScript, Programmer Defined Functions, Function Definitions, Random-Number Generation, Duration of Identifiers, Scope Rules, JavaScript Global Functions, Recursion, JavaScript arrays, JavaScript objects;

XML: Structuring Data, XML Namespaces, Document Type Definitions (DTDs) and Schemas, Document Type Definitions, W3C XML Schema Documents, XML Vocabularies, Chemical Markup Language (CML), Other Markup Languages, Document Object Model (DOM), DOM Methods, Simple API for XML (SAX), Extensible Style sheet Language (XSL), Simple Object Access Protocol (SOAP);

Web Servers: HTTP Request Types, System Architecture, Client-Side Scripting versus Server-Side Scripting, Accessing Web Servers, Microsoft Internet Information Services (IIS), Microsoft Personal Web. Server-side Scripting:

Introduction to PHP, String Processing and Regular Expressions, Form processing and Business logic, Dynamic content, Database connectivity, Applets and Servlets, JDBC connectivity, JSP and Web development Frameworks.

XML: Introduction to XML, Defining XML tags, their attributes and values, Document type definition, XML Schemas, Document Object model, XHTML, Parsing XML Data - DOM and SAX parsers

Text Books/ Reference:

1. Deitel, Deitel and Nieto, "Internet and Worldwide Web - How to Program", 5th Edition, PHI, 2011.
2. Bai and Ekedhi, "The Web Warrior Guide to Web Programming", 3rd Edition, Thomson, 2008.
3. Web Programming, building internet applications, Chris Bates 2nd edition, Wiley Dremtech
4. Java Server Pages – Hans Bergsten, SPD O'Reilly
5. Java Script, D.Flanagan, O'Reilly, SPD.
6. Beginning Web Programming-Jon Duckett WROX.
7. Programming world wide web, R.W. Sebesta. Fourth Edition, Pearson.
8. Internet and World Wide Web – How to program, Dietel and Nieto, Pearson.

Course Type	Code	Name of Course	L	T	P	Credit
DP	MC3203	***Web Technologies Lab***	0	0	3	2

Syllabus

Web Technologies Lab:

The Web Technologies Lab helps the students learn about web development and design. The lab uses technologies like HTML, CSS, JavaScript, PHP, and XML. Students explore and get hands-on experience using different web technologies.

Design and build static and dynamic websites and use JavaScript for dynamic effects.

Create web pages using HTML, CSS, and JavaScript
Create forms with various fields and appropriate front and validations
Use PHP to build web applications
Use PHP, JSP, and Servlets to handle sessions and cookies
Use JDBC to store, retrieve, and manage database interactions
Parse XML files using Java (DOM and SAX parsers)
Develop simple applications end-to-end using both client-side and server-side technologies

Text Books/ Reference:

1. Deitel, Deitel and Nieto, "Internet and Worldwide Web - How to Program", 5th Edition, PHI, 2011.
2. Bai and Ekedhi, "The Web Warrior Guide to Web Programming", 3rd Edition, Thomson, 2008.
3. Web Programming, building internet applications, Chris Bates 2nd edition, Wiley Dremtech
4. Java Server Pages – Hans Bergsten, SPD O'Reilly
5. Java Script, D.Flanagan, O'Reilly, SPD.
6. Beginning Web Programming-Jon Duckett WROX.
7. Programming world wide web, R.W. Sebesta. Fourth Edition, Pearson.
8. Internet and World Wide Web – How to program, Dietel and Nieto, Pearson.

Semester - VII						
Course Type	**Code**	**Name of Course**	**L**	**T**	**P**	**Credit**
DC	MC4102	***Applied Natural Language Processing***	3	0	0	3

Syllabus

Introduction to language processing – tokens, sentences, paragraphs

Regular expressions - extraction of information using Regex
Document Similarity measures - Cosine and cluster measures
Spelling correction - Edit distance

Information retrieval, extraction
Document Classification, Clustering, topic modeling techniques
Vector Space Model - word vectors, GloVe/Word2Vec model, word embedding

Text Classification, Clustering, and Summarization
Machine Learning, Perceptron
Back Propagation, Recurrent Neural network relevant to NLP
Machine Translation, Language Generation
Applications – Sentiment Analysis, Spam Detection, Resume Mining, AInstein

Text Books/ Reference:

1. Yoav Goldberg Neural Network Methods for Natural Language Processing, Morgan and Claypool (2017).
2. Dan Jurafsky and James Martin Speech and Language Processing, 3nd Edition,

ELECTIVES						
Course Type	**Code**	**Name of Course**	**L**	**T**	**P**	**Credit**
Elective		*Graph Neural Networks*	3	0	0	3

Syllabus

Representation learning

Graph representation Learning

Graph neural networks

Graph neural networks for node classification

The expressive power of Graph neural networks

Graph neural networks: Scalability

Interpretability in Graph neural networks

Graph neural networks: Adversarial robustness

Graph neural networks: Graph classification

Graph Neural Networks applications: Computer Vision, Natural Language Processing, etc.

Text Books/ Reference:

1. Lingfei Wu, Peng Cui, Jian Pei, Liang Zhao, `` Graph Neural Networks: Foundations, Frontiers, and Applications," Springer, 2022.

Course Type	Code	Name of Course	L	T	P	Credit
Elective		***Financial Mathematics***	3	0	0	3

Syllabus

Financial markets, Interest computation, value, growth and discount factors, derivative products, basic option theory: single and multiperiod binomial pricing models, Cox-Ross-Rubinstein (CRR) model, volatility, Black-Scholes formula for option pricing as a limit of CRR model, Greeks and hedging, Mean-Variance portfolio theory: Markowitz model, Capital Asset Pricing Model (CAPM), factor models, interest rates and interest rate derivatives, Binomial tree models.

Text Books/ Reference:

2. Capinski M. and Zastawniak T., "Mathematics for Finance- An introduction to financial engineering", Springer
3. Teall J. L. and Hasan I., "Quantitative methods for finance and investments", Blackwell Publishing
4. Hull J.C., "Options, futures and other derivatives", Pearson education
5. Chandra P., "Financial Management – Theory and Practice", Tata Mcgraw Hill
6. Wilmott P., Howison S. and Dewynne J., "The mathematics of financial derivatives- A student introduction", Cambridge University Press.

Course Type	Code	Name of Course	L	T	P	Credit
Elective		***Stochastic Models***	3	0	0	3

Syllabus

Definition and classification of general stochastic processes. Markov Chains: definition, transition probability matrices, classification of states, limiting properties. Markov Chains with Discrete State Space: Poisson process, birth and death processes. Renewal Process: renewal equation, mean renewal time, stopping time. Applications to queuing models. Markov Process with Continuous State Space: Introduction to Brownian motion.

Text Books/ Reference:

1. R. Aris, Mathematical Modelling Techniques, Dover, 1994.
2. C. L. Dym and E. S. Ivey, Principles of Mathematical Modelling, Academic Press, 1980.
3. M. S. Klamkin, Mathematical Modelling: Classroom Notes in Applied Mathematics, SIAM, 1986.
4. A. Friedman and W. Littman, Industrial Mathematics for Undergraduates, SIAM, 1994.
5. Bhat, U. N. and Miller, G.K., Elements of Applied Stochastic Processes, 3rd edition, John Wiley & Sons, New York, 2002.
6. Kulkarni, V.G., Modeling and Analysis of Stochastic Systems, 3rd Edition, Chapman and Hall/CRC, Boca Raton, 2017.
7. J. Medhi, Stochastic Models in Queuing Theory, Academic Press, 1991.
8. R. Nelson, Probability, Stochastic Processes, and Queuing Theory: The Mathematics of Computer Performance Modelling, Springer Verlag, New York, 1995
9. Sheldon M Ross: Stochastic Processes, John Wiley and Sons, 1996.
10. S Karlin and H M Taylor: A First Course in Stochastic Processes, Academic Press, 1975.

Course Type	Code	Name of Course	L	T	P	Credit
Elective		*Computational Methods for Differential Equations*	3	0	0	3

Syllabus

Ordinary Differential Equations: Initial Value Problems (IVP) and existence theorem. Truncation error, deriving finite difference equations. Single step methods for I order IVP- Taylor series method, Euler method, Picard's method of successive approximation, Runge Kutta Methods. Stability of single-step methods.
Multi-step methods for I order IVP - Predictor-Corrector method, Euler PC method, Milne and Adams Moulton PC method. System of first order ODE, higher order IVPs. Stability of multistep methods, root condition. Linear Boundary Value Problems (BVP), finite difference methods, shooting methods, stability, error and convergence analysis. Non-linear BVP, higher order BVP.
Partial Differential Equations: Classification of PDEs, Finite difference approximations to partial derivatives. Solution of one-dimensional heat conduction equation by Explicit and Implicit schemes (Schmidt and Crank Nicolson methods), stability and convergence criteria.
Laplace equation using standard five-point formula and diagonal five-point formula, Iterative methods for solving the linear systems. Hyperbolic equation, explicit/implicit schemes, method of characteristics. Solution of the wave equation. Solution of I order Hyperbolic equation. Von Neumann stability.

Text Books/ Reference:

1. ELEMENTARY NUMERICAL ANALYSIS An Algorithmic Approach (Mc-GrawHill) S. D. Conte, Carl de Boor
2. Numerical Solution of Partial Differential Equations: Finite Difference Methods (Oxford Applied Mathematics & Computing Science Series), G. D. Smith
3. Numerical Solution of Ordinary Differential Equations(Wiley), **Kendall E. Atkinson, Weimin Han, David E. Stewart**
4. Numerical Methods for Scientific and Engineering Computation (New Age International) M K Jain, S R K Iyengar, R K Jain.

Course Type	Code	Name of Course	L	T	P	Credit
Elective		***Functional Analysis***	3	0	0	3

Syllabus

Normed linear spaces, Banach spaces, Equivalence of norms on finite-dimensional spaces, Riesz lemma and characterization of finite dimensional normed spaces, Hamel basis and Schauder basis of normed spaces, Separable normed spaces.

Bounded linear operators, Continuous linear functionals, Hahn-Banach theorems (separation and extension theorems), Dual and bidual of a normed linear space, Dual of some classical spaces like c0, lp, Lp (for $p \geq 1$) and C(K); Reflexive spaces, weak convergence.

Uniform boundedness principle, Open mapping theorem, Closed graph theorem.

Transpose of an operator, Compact operators, Spectra of bounded linear operators and compact operators.

Hilbert spaces, Bessel's inequality, Orthonormal basis, Separable Hilbert space, Orthogonal projection, Riesz Representation Theorem.

Operators on Hilbert spaces: Adjoint of an operator, Normal, unitary, self-adjoint operators, positive operators and their spectra, Spectral theorem for compact self-adjoint operators.

Text Books/ Reference:

1. J. B. Conway, A course in functional analysis, GTM (96), Springer, 2007
2. B. V. Limaye, Functional Analysis, 3rd Ed., New Age International Publishers, 2014
3. M. Reed and B. Simon, Methods of Modern Mathematical Physics, Vol. 1: Functional Analysis, Academic Press, 1980
4. G. Bachman and L. Narici, Functional Analysis, 2nd Ed., Dover Publication, 1998
5. S. Kesavan, Functional Analysis, TRIM series, Hindustan Book Agency, 2009
6. Yosida, K., Functional Analysis, 6th Ed., Springer-Verlag Berlin Heidelberg, 1995
7. Rajendra Bhatia, Notes on Functional Analysis, Hindustan Book Agency, 2015
8. M. T. Nair, Functional analysis: A first course, PHI-Learning, New Delhi, Fourth Print, 2014

Course Type	Code	Name of Course	L	T	P	Credit
Elective		***Multivariate Calculus and Measure Theory***	3	0	0	3

Syllabus

Functions of several variables, open sets in Euclidean spaces, limits, continuity, differentiation of functions of several variables; Inverse function theorem; Implicit function theorem; Review of Riemann-Stieltjes integral; Lebesgue measure, Lebesgue outer measure, Lebesgue measurable sets, measure on an arbitrary sigma-algebra; Measurable functions, integral of a simple measurable function, integral of positive measurable functions; Lebesgue's monotone convergence theorem; Lebesgue integrability; Dominated convergence theorem; Lp-spaces; Differentiation and fundamental theorem for Lebesgue integration; Product measure; Statement of Fubini's theorem.

Text Books/ Reference:

1. Royden H L, Real Analysis, Prentice Hall of India (1995).
2. Rudin W, Real and Complex Analysis, McGraw-Hill, International Editions (1987).
3. Barra G D, Measure and Integration, Wiley Eastern Ltd (1981).
4. Edwards H M, Advanced Calculus: A Differential Forms Approach, Birkhauser (1994).
5. Folland G B, Advanced Calculus, Pearson (2012).
6. Rana I K, An Introduction to Measure and Integration, Narosa Publishing Agencies (1997).

Course Type	Code	Name of Course	L	T	P	Credit
Elective		***Computational Number Theory***	3	0	0	3

Syllabus

Arithmetic of Integers, multi-precision arithmetic, divisibility, gcd, modular arithmetic, linear congruences, Chinese remainder theorem, polynomial congruences and Hensel lifting, orders and primitive roots, quadratic residues.
Representation of finite fields, Prime and extension fields, representation of extension fields, polynomial basis, primitive elements, normal basis, optimal normal basis, irreducible polynomials.
Algorithms for polynomials, root-finding and factorization, polynomials over finite fields, Lenstra-Lenstra-Lovasz algorithm.
Elliptic curves,The elliptic curve group, elliptic curves over finite fields, Schoof's point counting algorithm.
Primality testing algorithms, Fermat test, Miller-Rabin test, Solovay-Strassen test, AKS test.
Integer factoring algorithms, Trial division, Pollard rho method, p-1 method, CFRAC method, quadratic sieve method, elliptic curve method.
§Computing discrete logarithms over finite fields -- Baby-step-giant-step method, Pollard rho method, Pohlig-Hellman method, index calculus methods, linear sieve method, Coppersmith's algorithm.
Applications -- Algebraic coding theory, cryptography.

Text Books/ Reference:

1. *A. Das, Computational Number Theory, CRC Press.* [Main Text]
2. V. Shoup, A computational introduction to number theory and algebra, Cambridge University Press.
3. H. Cohen, A course in computational algebraic number theory, Springer-Verlag.
4. J. von zur Gathen and J. Gerhard, Modern computer algebra, Cambridge University Press.
5. J. H. Silverman and J. Tate, Rational points on elliptic curves, Springer International Edition.
6. I. Niven, H. S. Zuckerman and H. L. Montgomery, An Introduction to the Theory of Numbers, John Wiley and Sons.
7. G. H. Hardy and E. M. Wright, An Introduction to the Theory of Numbers, Oxford University Press.
8. J. von zur Gathen and J. Gerhard, Modern computer algebra, Cambridge University Press.

Course Type	Code	Name of Course	L	T	P	Credit
Elective		***Convex Optimization***	3	0	0	3

Syllabus

Convex analysis: convex sets, convex cones, polyhedral sets, extreme points and directions. Convex functions, properties and tests for convexity, operations that preserve convexity, conjugate function.
Convex optimization problems: standard form, equality and inequality constraints, slack variables, eliminating equality and inequality constraints. Local and global optima. Optimality criterion for unconstrained, equality constrained and inequality constrained problems.
Linear optimization problems with examples, linear and generalized linear-fractional programming. Quadratic problems with examples. Second order cone programming – robust linear programming, linear programming with random constraints. Geometric programming with examples. Generalized inequality constraints – conics form problems, semidefinite programming, examples.
Handling non-convexity: Lagrangian duality theory – Lagrangian dual function, strong and weak duality, duality gap. Certificate of suboptimality and stopping criteria, complementary slackness. KKT optimality conditions. Solving the primal via dual.

Text Books/ Reference:

1. S. Boyd and L. Vandenberghe, Convex optimization, Cambridge University Press, 2008.
2. M.S. Bazaraa, H.D. Sherali and C.M. Shetty, Nonlinear Programming, 3/e, Wiley, 2006.
3. D. P. Bertsekas, Nonlinear programming, Athena Scientific, 1999.
4. D. G. Luenberger and Y. Ye, Linear and nonlinear programming, 3/e, Springer, 2008.

Course Type	Code	Name of Course	L	T	P	Credit
Elective		*High-Performance Computing*	3	0	3	6

Syllabus

Parallel Processing Concepts; Levels and model of parallelism: instruction, transaction, task, thread, memory, function, data flow models, demand-driven computation; Parallel architectures: superscalar architectures, multi-core, multi-threaded, server and cloud; Fundamental design issues in HPC: Load balancing, scheduling, synchronization and resource management; Operating systems for scalable HPC; Parallel languages and programming environments; OpenMP, Pthread, MPI, java, Cilk; Performance analysis of parallel algorithms; Fundamental limitations in HPC: bandwidth, latency and latency hiding techniques; Benchmarking HPC: scientific, engineering, commercial applications and workloads; Scalable storage systems: RAID, SSD cache, SAS, SAN; HPC based on cluster, cloud, and grid computing: economic model, infrastructure, platform, computation as service; Accelerated HPC: architecture, programming and typical accelerated system with GPU, FPGA, Xeon Phi, Cell BE; Power-aware HPC Design: computing and communication, processing, memory design, interconnect design, power management; Advanced topics: peta scale computing; big data processing, optics in HPC, quantum computers.

HPC programming assignments: Hands on experiment and programming on parallel machine and HPC cluster using Pthread, OpenMP, MPI, Nvidia Cuda and Cilk. Also there will be some hands on experiments on standard multiprocessor simulator or cloud simulator.

Text Books/ Reference:

1. Georg Hager and Gerhard Wellein. Introduction to High Performance Computing for Scientists and Engineers (1st ed.). CRC Press, Chapman & Hall/CRC Computational Science, India, 2010.
2. Vipin Kumar , Ananth Grama , Anshul Gupta , George Karypis. Introduction to Parallel Computing (2nd ed.). Pearson India . 2003.
3. John L. Hennessy and David A. Patterson. Computer Architecture: A Quantitative Approach (5th ed.). Elsevier India Pvt. Ltd. 2011.
4. David B. Kirk and Wen-mei W. Hwu. Programming Massively Parallel Processors: A Hands-On Approach (1st ed.). Elsevier India Pvt. Ltd. 2010.
5. Michael T. Heath. Scientific Computing: An Introductory Survey (2nd ed.). McGraw Hill Education (India) Private Limited, 2011

Course Type	Code	Name of Course	L	T	P	Credit
Elective		***Mathematical Modeling and Numerical Simulation***	3	0	0	3

Syllabus

Model and its different types, Finite models, Statistical models, Stochastic models, Formulation of a model, Laws and conservation principles, Discrete and continuous models, Manipulation into its most respective form, Evaluation of a model. Case studies, Continuum model, Transport phenomena, Diffusion and air pollution models, Microwave heating, Communication and Information technology.

Software Support: MATHEMATICA, LSODE, GNUPLOT, MATLAB.

Text Books/ Reference:

1. R. Aris, Mathematical Modelling Techniques, Dover, 1994.
2. C. L. Dym and E. S. Ivey, Principles of Mathematical Modelling, Academic Press, 1980.
3. M. S. Klamkin, Mathematical Modelling: Classroom Notes in Applied Mathematics, SIAM, 1986.
4. A. Friedman and W. Littman, Industrial Mathematics for Undergraduates, SIAM, 1994.

Course Type	Code	Name of Course	L	T	P	Credit
Elective		***Numerical Analysis***	3	0	0	3

Syllabus

Errors: Floating-point approximation of a number, Loss of significance and error propagation, Stability in numerical computation.

Linear Systems: Gaussian elimination with pivoting strategy, Gauss-Jordon method, LU factorization, Residual corrector method, Solution by iteration: Jacobi and Gauss-Seidel with convergence analysis, Matrix norms and error in approximate solution, Eigenvalue problem: Power method, Gershgorin's theorem, QR factorization and Conjugate-Gradient method.

Nonlinear Equations: Bisection method, Regula-Falsi, Secant method, Newton-Raphson method, Fixed-point iteration method, Rate of convergence, Solution of a system of nonlinear equations.

Interpolation by Polynomials: Lagrange interpolation, Newton interpolation and divided differences, Error of the interpolating polynomials, Piecewise linear and cubic spline interpolation, Trigonometric interpolation, Hermite Interpolation, Data fitting and least-squares approximation problem.

Differentiation and Integration: Difference formulae, Some basic rules of integration, Adaptive quadratures, Gaussian rules, Composite rules, Error formulas.

Ordinary Differential Equations: Taylor's, Euler's and modified Euler's method, Second and Fourth order Runge-Kutta methods.

Text Books/ Reference:

1. K. E. Atkinson, An Introduction to Numerical Analysis, 2nd Edition, Wiley-India, 1989.
2. S. D. Conte and C. de Boor, Elementary Numerical Analysis - An Algorithmic Approach, 3rd Edition, McGraw-Hill, 1981.
3. R. L. Burden and J. D. Faires, Numerical Analysis, 7th Edition, Thomson, 2001.
4. C.F. Gerald, P.O. Wheatley: Applied Numerical Analysis, Addison-Wesley, 1994
5. M K Jain, S R K Iyengar, R K Jain., Numerical Methods for Scien1fic and Engineering Computation, New Age International.

Course Type	Code	Name of Course	L	T	P	Credit
Elective		***Partial Differential Equations***	3	0	0	3

Syllabus

Formulation, Linear and quasi-linear first order partial differential equations, Paffian equation, Condition for integrability, Lagrange's method for linear equations. First order non-linear equations, method of Charpit - method of characteristics.

Equations of higher order: Method of solution for the case of constant coefficients, Equations of second order reduction to canonical forms, Characteristic curves and the Cauchy problem, Riemann's method for the solution of linear hyperbolic equations, Monge's method for the solution of non-linear second order equations.

Method of solution by separation of variables. Laplace's equations: Elementary solutions, Boundary value problems, Green's functions for Laplace's equation, Solution using orthogonal functions. Wave equations: One dimensional equation and its solution in trigonometric series, Riemann-Volterra solution, vibrating membrane. Diffusion equations: Elementary solution, Solution in terms of orthogonal functions.

Text Books/ Reference:

1. I.N. Sneddon: Elements of Partial Differential Equations, McGraw Hill, New York, 1957.
2. Ioannis P Stavroulakis, Stepan A Tersian : Partial Differential Equations: An Introduction with MATHEMATICA and MAPLE, World scientific, Singapore, 2004.
3. P. Prasad, Renuka Ravindran: Partial Differential Equations, New Age International, 1985.
4. T. Amaranath: An elementary course in Partial differential equations, Narosa Pub., New Delhi, 2009.

Course Type	Code	Name of Course	L	T	P	Credit
Elective		***Pattern Recognition***	3	0	0	3

Syllabus

Basics of Probability, Random Processes and Linear Algebra: Probability: independence of events, conditional and joint probability, Bayes' theorem; Random Processes: Stationary and nonstationary processes, Expectation, Autocorrelation, Cross-Correlation, spectra; Linear Algebra: Inner product, outer product, inverses, eigen values, eigen vectors; Bayes Decision Theory

Bayes Decision Theory: Minimum-error-rate classification, Classifiers, Discriminant functions, Decision surfaces, Normal density and discriminant functions, discrete features

Parameter Estimation Methods: Maximum-Likelihood estimation: Gaussian case; Maximum a Posteriori estimation; Bayesian estimation: Gaussian case

Unsupervised learning and clustering: Criterion functions for clustering; Algorithms for clustering: K-Means, Hierarchical and other methods; Cluster validation; Gaussian mixture models; Expectation-Maximization method for parameter estimation; Maximum entropy estimation

Sequential Pattern Recognition: Hidden Markov Models (HMMs); Discrete HMMs; Continuous HMMs

Nonparametric techniques for density estimation: Parzen-window method; K-Nearest Neighbour method

Dimensionality reduction: Fisher discriminant analysis; Principal component analysis; Factor Analysis

Linear discriminant functions: Gradient descent procedures; Perceptron; Support vector machines

Non-metric methods for pattern classification: Non-numeric data or nominal data; Decision trees: CART

Text Books/ Reference:

1. R.O. Duda, P.E. Hartand, D.G. Stork, Pattern Classification, John Wiley, 2002.
2. C.M. Bishop, Neural Networks and Pattern Recognition, Oxford University Press (Indian Edition), 2003.
3. Bishop C M, Pattern Recognition and Machine learning, Springer, 2006.
4. S.Theodoridis and K.Koutroumbas, Pattern Recognition, 4th Ed., Academic Press, 2009

Course Type	Code	Name of Course	L	T	P	Credit
Elective		*Big Data Analytics*	3	0	0	3

Syllabus

Introduction to big data: Introduction to Big Data Platform – Challenges of Conventional Systems - Intelligent data analysis – Nature of Data - Analytic Processes and Tools - Analysis vs Reporting.

Mining data streams: Introduction To Streams Concepts – Stream Data Model and Architecture - Stream Computing - Sampling Data in a Stream – Filtering Streams – Counting Distinct Elements in a Stream – Estimating Moments – Counting Oneness in a Window – Decaying Window - Real time Analytics Platform(RTAP) Applications - Case Studies - Real Time Sentiment Analysis- Stock Market Predictions. Hadoop: History of Hadoop- the Hadoop Distributed File System – Components of Hadoop Analysing the Data with Hadoop- Scaling Out- Hadoop Streaming- Design of HDFS-Java interfaces to HDFS Basics- Developing a Map Reduce Application-How Map Reduce Works- Anatomy of a Map Reduce Job run-Failures-Job Scheduling-Shuffle and Sort – Task execution - Map Reduce Types and Formats- Map Reduce Features Hadoop environment. Frameworks: Applications on Big Data Using Pig and Hive – Data processing operators in Pig – Hive services – HiveQL – Querying Data in Hive - fundamentals of HBase and ZooKeeper - IBM Info Sphere Big Insights and Streams. Predictive Analytics- Simple linear regression- Multiple linear regression- Interpretation 5 of regression coefficients. Visualizations - Visual data analysis techniques- interaction techniques - Systems and applications.

Text Books/ Reference:

1. Michael Berthold, David J. Hand, "Intelligent Data Analysis", Springer, 2007.
2. Tom White "Hadoop: The Definitive Guide" Third Edition, O'reilly Media, 2012.
3. Chris Eaton, Dirk DeRoos, Tom Deutsch, George Lapis, Paul Zikopoulos, "Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data", McGrawHill Publishing, 2012.
4. Anand Rajaraman and Jeffrey David Ullman, "Mining of Massive Datasets", CUP, 2012.
5. Bill Franks, "Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics", John Wiley& sons, 2012.
6. Glenn J. Myatt, "Making Sense of Data", John Wiley & Sons, 2007.
7. Pete Warden, "Big Data Glossary", O'Reilly, 2011.
8. Jiawei Han, Micheline Kamber "Data Mining Concepts and Techniques", 2 nd Edition, Elsevier, Reprinted 2008.
9. Da Ruan, Guoquing Chen, Etienne E.Kerre, Geert Wets, "Intelligent Data Mining", Springer, 2007.
10. Paul Zikopoulos, Dirkde Roos, Krishnan Parasuraman, Thomas Deutsch, James Giles , David Corrigan, "Harness the Power of Big Data The IBM Big Data Platform", Tata McGraw Hill Publications, 2012.
11. Arshdeep Bahga, Vijay Madisetti, "Big Data Science & Analytics: A HandsOn Approach ",VPT, 2016
12. Bart Baesens "Analytics in a Big Data World: The Essential Guide to Data.

Course Type	Code	Name of Course	L	T	P	Credit
DE		***Deep Learning & Applications***	3	0	3	5

Syllabus

Introduction to Deep Learning, Bayesian Learning, Decision Surfaces, Linear Classifiers, Linear Machines with Hinge Loss, Optimization Techniques, Gradient Descent, Batch Optimization, Introduction to Neural Network, Multilayer Perceptron, Back Propagation Learning, Unsupervised Learning with Deep Network, Autoencoders, Convolutional Neural Network, Building blocks of CNN, Transfer Learning, Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam, Effective training in Deep Net- early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization, Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network, Fully Connected CNN etc., Classical Supervised Tasks with Deep Learning, Image Denoising, Semanticd Segmentation, Object Detection etc, LSTM Networks, Generative Modeling with DL, Variational Autoencoder, Generative Adversarial Network Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam.

Text Books/ Reference:

1. Deep Learning- Ian Good felllow, Yoshua Benjio, Aaron Courville, The MIT Press
2. Pattern Classification- Richard O. Duda, Peter E. Hart, David G. Stork, John Wiley & Sons Inc.

Course Type	Code	Name of Course	L	T	P	Credit
Elective		***Abstract Algebra***	3	0	0	3

Syllabus

Group theory: Binary operation, and its properties, Definition of a group, Groups as symmetries, Examples: cyclic, dihedral, symmetric, matrix groups, Subgroups, Cosets, normal subgroups and quotient groups, Conjugacy classes, Lagrange's theorem, The isomorphism theorems, Direct and semi-direct products, Group automorphisms, Symmetric group and alternating group, Actions of groups on sets, Cayley's theorem, orbit and stabilizers, Class equations, p-groups, Sylow's theorem and applications: simplicity of groups, Classification of finite abelian groups.

Ring Theory: Definition and examples, Ring homomorphism, Ideals and Quotient rings, Chinese Remainder Theorem, Integral Domain and quotient fields, Unique factorization domain, Principal Ideal domain, Euclidean domain, Gauss lemma, Polynomial Rings, Irreducibility of Polynomials, Ring of Gaussian Integers.

Text Books/ Reference:

4. J. Gallian: Contemporary Abstract Algebra, Narosa Books Pvt. Ltd.
5. I. N. Herstein: Topics in Algebra, Wiley.
6. D. S. Dummit and R.M. Foote, Abstract Algebra, Wiley.
7. M. Artin, Algebra, PHI.
8. N. Jacobson, Basic Algebra I, Basic Algebra II, Dover Publications.

Course Type	Code	Name of Course	L	T	P	Credit
Elective		***Statistical Learning: Theory and Applications***	3	0	0	3

Syllabus

Overview of nearest neighbor, decision theory, roughness penalty regression, Bayesian method; Linear and quadratic discriminant analysis, regularized logistic regression, separating hyperplanes; Basis expansion and regularization: splines, filtering, and feature extraction, bias-variance trade-off; Kernel smoothing methods: kernel density estimation and classification, naive Bayes classifier, radial functions; Model assessment and selection: AIC, BIC, VC dimension, cross-validation, bootstrap; Regression tree, classification tree; Neural network: multi- layer perceptron, feed-forward and recurrent networks, self-organizing map; Support vector machines, data depths; Cluster analysis: K means clustering, independent component analysis; Random forest.

Text Books/ Reference:

1. Hastie T, Tibshirani R and Friedman J, The Elements of Statistical Learning: Data Mining, Inference and Prediction, 2nd Edition, Springer (2013).
2. Webb A R, Statistical Pattern Recognition, 3rd Edition, Wiley (2011).
3. Devroye L, Gyorfi L and Lugosi G, A Probabilistic Theory of Pattern Recognition, 1st Edition, Springer (1996).
4. Duda R O, Hart P E and Stork D G, Pattern Classification, 2nd Edition, Wiley (2011)
5. Haykin S, Neural Networks: A Comprehensive Foundation, 2nd Edition, Pearson Prentice Hall (1999).
6. Vapnik V N, The Nature of Statistical Learning Theory, 2nd Edition, Springer (2000)

30.11.2025

Annexure-2

FEE STRUCTURE for Ph.D. Programme
(With effective from Spring Semester 2025-26

Sl. No.	Particulars	Regular (Gen./OBC/EWSs)	Regular (SC/ST/PD)	Industry-Sponsored and Self-Sponsored
A.	One-Time Payment at the Time of Admission (Non-Refundable)			
1	Admission Fee	500	500	1000
2	Identity Card	100	100	100
3	Placement Fee	1500	1500	0
4	Convocation Fee	2000	2000	2000
5	Alumni Subscription	1000	1000	1000
6	Migration Fee	500	500	500
7	Thesis Evaluation Fee	10000	10000	10000
	Total	**15600**	**15600**	**14600**
B.	Caution Deposit (Refundable) Payable at the Time of Admission			
1	**Institute Caution Money**	**5000**	**5000**	**5000**
C.	Semester Fee (Each Semester) Non-Refundable			
1	Examination Fee	500	500	500
2	Registration/Enrolment Fee	400	400	400
3	Gymkhana Fee	1000	1000	1000
4	Campus Services & Utility	500	500	0
5	Library Fee	200	200	200
6	Tuition Fee*	5000	Nil	15000
7	Institute Development Fund	10000	10000	10000
8	Laboratory Fee	800	800	800
	Total	**18400**	**13400**	**27900**
D.	Annual Fees			
1	Medical Insurance Fee	2000	2000	**0**
2	Student Brotherhood Fund	500	500	**500**
3	Benevolent Fund	1000	1000	**1000**
4	Modernization Fee	700	700	**700**
	Total	**4200**	**4200**	**2200**
Amount Payable at the time of admission (Total of A, B, C and D)				
	Total During Admission (A+B+C+D)	**43200**	**38200**	**49700**
	Every Autumn Semester (C+D)	**22600**	**17600**	**30100**
	Every Spring Semester '(C)	**18400**	**13400**	**27900**

#Students have an option to donate the caution deposit to the Institute.
*SC, ST, and PD students are exempted from paying the tuition fees. There is no exemption in fee for the self-sponsored/project sponsored/Part-time students.

Note

1. There are no hostel fees. However, students opting for hostel facility need to pay "Hostel Caution Deposit" of ₹ 4000/- during the admission.
2. Student need to pay additional amount of ₹ 5,500.00 (approx.) per month to the mess vendor. This is an indicative amount and will be charge as per actual.
3. Fee structure and fee amounts are subject to change from time to time.

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Annexure-3

FEE STRUCTURE FOR 2 YEAR M.TECH. PROGRAMMES

SL.NO.	PARTICULARS	GEN/OBC/EWS (Regular)	SC/ST/PWD (Regular)	Sponsored	Foreign ICCR/SAARC (USD)	Foreign Non SAARC (USD)	Self-Financed
A	**One-time payment at the time of Admission (Non-Refundable) (Rs.)**						
1	Admission Fee	500	500	13000*	150*	150*	1000
2	Identity Card	100	100				100
3	Placement Fee	1500	1500				1500
4	Convocation Fee	2000	2000				2000
5	Alumni Fee	1000	1000				1000
6	Migration Fee	500	500				500
	Total	**5600**	**5600**	**13000**	**150**	**150**	**6100**
B	**Caution Deposits (Refundable) payable at the time of Admission (Rs.)**						
1	Institute Caution Money	**5000**	**5000**	**5000**	**50**	**50**	**5000**
C	**Semester Fee (Each Semester) Non-Refundable (Rs.)**						
1	Examination	500	500	9000	100	100	500
2	Registration/Enrolment	200	200				200
3	Gymkhana Fee	1000	1000				1000
4	Campus Service and Utility	500	500				500
5	Library Fee	200	200				200
	Total	**2400**	**2400**	**9000**	**100**	**100**	**2400**
D	**Annual Fees (Rs.)**						
1	Medical Insurance Fee	2000	2000	8700	100	100	2000
2	Student Brotherhood Fund	500	500				500
3	Benevolent Fund	1000	1000				1000
4	Modernization Fee	700	700				700
	Total	**4200**	**4200**	**8700**	**100**	**100**	**4200**
E	**Tuition Fee (Each Semester) (Rs.)**						
1	2 Year M.Tech	**10000**	**Nil**	**87000**	**1000**	**2000**	**25,000**

BROAD BREAKDOWN BY SEMESTER:

Description	1st Sem	2nd Sem	3rd Sem	4th Sem	Total Fee
GEN/OBC/EWS (Regular) (₹)	27200	12400	16600	12400	68600
SC/ST/PWD (Regular) (₹)	17200	2400	6600	2400	28600
Self-Sponsored (₹)	42700	27400	31600	27400	1,29,100
Sponsored (₹)	1,22,700	96000	104700	96000	4,19,400
Foreign ICCR/SAARC (USD)	1400	1100	1200	1100	4800
Foreign Non SAARC (USD)	2400	2100	2200	2100	8800

Notes:

1. Students have the option to donate the caution deposit to the Institute.
2. Placement fee for Sponsored and Foreign student is zero.
3. Regular Students residing in Hostel need to pay Rs. 30,000/- per semester and a caution deposit of Rs. 4000/- during admission. For sponsored and foreign national, Hostel fee is ₹ 35000/- and USD 400, respectively.
4. Student need not pay an additional amount of Rs. 5,500 (approx.) per month to the mess vendor.
5. This is an indicative amount and will be charged as per actual.
6. Fee structure and fee amounts are subject to change from time to time.

30.11.2025

Annexure-4

No Objection-Cum-Sponsorship Certificate from Employing Organization on Letterhead
(for Sponsored candidates)

The applicant Mr./Ms. ..... is working as ..... (Designation) in the scale of pay of Rs..... Since ..... in our organization.

- If Shri/Smt./Miss. _____ is admitted to the M.Tech. programme, we shall allow him/ her to undergo the PG programme at IIPE Visakhapatnam.
- During the period of PG programme, the candidate will be permitted to carry out his / her research work at our laboratories/organization and will be given the required facilities, if available.
- No part of the work carried out in fulfilment of the programme will be utilised commercially/submission of manuscript/applying for a patent without the approval of IIPE, Visakhapatnam and on terms mutually agreed by IIPE, Visakhapatnam and this organisation.

Seal and Address of the organisation

Signature (with full name and designation)
of Head of the Organization

Date:

Place:

30.11.2025

Annexure-5

Course Type	Course Code	Name of course	L	T	P	Credit
Core	ME3203	Mechanical Engineering Lab-II	0	0	3	2
Syllabus Modification proposed by	Dr. Santosh kumar Senapati, Assistant professor, Department of Mechanical Engineering.					

Experiment No	Title of the Experiment
1	Performance testing of a vapor compression refrigeration unit
2	Performance testing of an air-conditioning unit
3	Performance testing of a heat pump unit
4	Performance testing of a reciprocating compressor
5	Performance testing of a blower
6	Thermal Performance Testing of Compact Cooling Modules
7	Performance testing of Microchannel Cooling
8	Performance evaluation of Solar Air Flow Channels
9	Experimental Investigation of Thermal–Hydraulic Performance of nano-fluids
10	Determination of heat transfer coefficient in fluidized bed combustion
11	Pressure drop and holdup studies for a fluidized bed
12	Characteristics of a convergent-divergent nozzle
13	Determination of flame velocity and burner loading in premixed combustion of gaseous fuel
14	Determination of boiler efficiency and condenser heat transfer coefficient of an electrical boiler

Course Type	Course Code	Name of Course	L	T	P	Credit
CORE		**Nanotribology and Nanomechanics: Fundamentals and Applications**	3	1	0	4

Name of the Faculty	Dr. Deepak Kumar	**Scheme of Evaluation**	
Designation	Assistant Professor	Assignment+Attendance	20 Marks
Year/Semester	I/I	Mid Semester Examination	30 Marks
UG/PG/Ph.D.	PG/Ph.D.	End Semester Examination	50 Marks
Branch	All Engineering	**Total**	**100 Marks**

Course Objective

- Provide foundational understanding of tribological phenomena at the nanoscale, including friction, wear, and lubrication.
- Introduce atomic and molecular scale surface forces and their impact on nanotribological behavior.
- Familiarize students with experimental methods and instrumentation used to study nanotribology.
- Develop capability to analyze surface interactions and contact mechanics relevant to nanotribology.
- Explore applications of nanotribology in MEMS/NEMS, biomedical devices, energy, and petroleum engineering.
- Equip students to critically assess current research, trends, and industrial uses of nanotribology.
- Encourage problem-solving skills for real-world engineering challenges involving nanoscale tribological systems.

Learning Outcomes

Upon completing the course, students will be able to:

- Explain key concepts of friction, wear, and lubrication at the nanoscale.
- Differentiate between macro, micro, and nanoscale tribological processes.
- Describe the roles of van der Waals, capillary, electrostatic, and adhesive forces in nanotribology.
- Analyze surface phenomena such as surface energy, adhesion, and roughness in tribological contexts.
- Apply knowledge of contact mechanics to nanoscale interfaces.
- Utilize and interpret data from atomic force microscopy (AFM), friction force microscopy (FFM), nanoindentation, and other nano-characterization tools.

- Evaluate the tribological performance of materials and lubricants used in energy and petroleum applications.
- Discuss challenges and limitations in experimental nanotribology research.
- Identify current trends and applications of nanotribology in advanced technologies and industrial sectors.

Unit No	Topics	Learning Outcome	Content compared with Which University
1.	**Introduction and Fundamentals:** Basics of tribology: friction, wear, and lubrication at the nanoscale. Historical development and significance of nanotribology. Distinction between macro, micro, and nanotribology. Typical applications (hard disk drives, MEMS, biomedical devices). Overview of nanoscale forces: van der Waals, capillary, adhesive interactions. Mechanical behavior fundamentals: elasticity, plasticity, size effects.	• **Explain** nanotribology fundamentals: friction, wear, lubrication, and nanoscale forces. • **Differentiate and apply** macro-, micro-, and nanotribology to applications, linking to elasticity, plasticity, and size effects.	University of Utah, USA; SRMIST; IIT Delhi
2.	**Surface Phenomena and Contact Mechanics:** Real versus nominal contact area at nanoscales. Surface energy, work of adhesion, and their measurement. Clean, contaminated, and lubricated surface distinctions. Surface roughness effects in atomic-scale tribology. Contact mechanics theories for nanoscale contacts. Mechanical response: elasticity, plasticity, hardness of nanocontacts.	• **Analyze** surface phenomena and their role in nanoscale contact (energy, adhesion, contamination, lubrication, roughness). • **Apply** contact mechanics theories to assess elasticity, plasticity, and hardness of nanocontacts.	IIT Delhi; Imperial College London

3.	**Experimental Methods in Nanotribology:** Atomic Force Microscopy (AFM) and Friction Force Microscopy (FFM). Nanoindentation and depth-sensing indentation techniques. Surface and sub-surface characterization tools (SEM, TEM, XPS, SPM). In-situ tribology measurements and wear analysis. Experimental limitations and artifact identification.	• **Explain** experimental methods in nanotribology (AFM, FFM, nanoindentation, surface characterization). • **Evaluate** in-situ measurements, wear analysis, and identify experimental limitations and artifacts.	MIT; IIT Delhi; AVS Short Courses; Society of Tribologist and Lubricant Engineers
4.	**Applications and Current Trends:** Nanotribology in MEMS/NEMS devices and thin film coatings. Biological nanotribology: cartilage, synovial fluid, gecko adhesion. Environmental and chemical effects on nanoscale tribology. Advances in solid and liquid nanoscale lubricants. Case studies from literature, current research, industrial applications. Energy and petroleum industry **applications.**	• **Apply** nanotribology concepts to MEMS/NEMS, coatings, biological systems, and energy applications. • **Evaluate** current trends, advanced lubricants, and case studies from research and industry.	University of Utah; MIT; Imperial College London

Text Book:

1. "Handbook of Micro/Nano Tribology" by Bharat Bhushan (2nd Edition), CRC Press, 2020.
2. "Elements of Friction Theory and Nanotribology" by Enrico Gnecco and Ernst Meyer, Cambridge University Press, 2015
3. "Nanotribology and Nanomechanics" by Bharat Bhushan (latest edition), Springer, 2017.

Reference books:

1. "Introduction to Tribology" by Bharat Bhushan, Wiley, 2013.
2. "Nanotribology: Critical Assessments and Research Needs" by Stephen M. Hsu, Z. Charles Ying, 2003, Springer.
3. "Physics and Chemistry of Micro-Nanotribology" by Shizhu Wen, Jianbin Luo, Yuanzhong Hu, ASTM, 2008.

30.11.2021

Annexure-6

Indian Institute of Petroleum and Energy
Visakhapatnam

M. Tech. Programme
in
Chemical Engineering

30.11.2021

Overview:
Indian Institute of Petroleum and Energy (IIPE), Visakhapatnam is an "Institute of National Importance" established under the Act of Parliament. It aims to provide highly skilled manpower for the relevant sector through strong fundamental technical education and carry out collaborative research to develop the technologies that will bridge the gaps towards sustainable growth. To achieve this, it is proposed to start a two year M.Tech program in Chemical Engineering from the 2026-2027 academic year.

Eligibility for M.Tech programme in Chemical Engineering:
The eligibility criteria for admission into M.Tech. programme is similar to that adopted by the "Indian Institutes of Technology" (IITs) and other premier institutions in India.

Program	Eligibility
M.Tech in Chemical Engineering	**Regular Category:** A 4 year B.Tech or an equivalent degree in Chemical Engg./Chemical Technology/Bio-Chemical Engg./Bio-Technology/Energy Engg./Petrochemical Engg./Electrochemical Engg. with a first class or minimum 60% marks or 6.0 CGPA (55% marks or 5.5 CGPA for SC/ST students) in the qualifying exam. **In addition, the applicant must also have a valid GATE score.**
	Industry Sponsored Category: A 4-year B.Tech. or an equivalent degree in Chemical Engg./Chemical Technology/Bio-Chemical Engg./Bio-Technology/Energy Engg./Petrochemical Engg./Electrochemical Engg. with a first class or minimum 60% marks or 6.0 CGPA (55% marks or 5.5 CGPA for SC/ST students) in the qualifying exam. The candidate shall submit a no-objection certificate from the sponsoring organisation/industry in the prescribed format at the time of the interview. Written exam/Interview will be held by the Department for shortlisting the candidates. No stipend will be provided for such candidates.
	Self-Sponsored Category: A 4 year B.Tech. or an equivalent degree in Chemical Engg./Chemical Technology/Bio-Chemical Engg./Bio-Technology/Energy Engg./Petrochemical Engg./Electrochemical Engg. with a first class or minimum 60% marks or 6.0 CGPA (55% marks or 5.5 CGPA for SC/ST students) in the qualifying exam. Written exam/Interview will be held by the Department for shortlisting the candidates. No stipend will be provided for such candidates.

	International Category: Four years Bachelor's degree in Chemical Engg./Chemical Technology/Bio-Chemical Engg./Bio-Technology/Energy Engg./Petrochemical Engg./Electrochemical Engg., with a good academic record along with SOP, letters of reference and work experience as the case may be. For international students with UG degree from India a valid GATE score /online interview is also required. The Department/ School/ Centre may put additional requirements for admission.

No. of Seats: 22

i. 50-75% Foreign Nationals

ii. 25-75% For Indian sponsored (Both Industry Sponsored & self-Financed)

iii. 25-75% For Regular

This is the general range which can be followed. However, in case of vacant seat(s) in any category, the same can be filled up by other category.

Stipend: As per the institute policy.

Start date: 2026-27 Academic year

Fee Structure: As per the institute policy.

Reservation: As per Government rules

Academic requirement:

The following Table lists the minimum residence, maximum duration, and credit requirements for obtaining M.Tech. degree.

Total Credits required for Graduation	Credits to be earned through Course Work	Credits to be earned through Thesis Work	Minimum Residence (Semesters)	Maximum Duration (Semesters)
76	38	38	4	8

List of Subjects for M.Tech in Chemical Engineering

Semester - I

S. No.	Course Code	Course Title	Components			
			L	T	P	C
1		Mathematical Methods in Chemical Engineering	3	0	0	3
2		Advanced Transport Phenomena	3	0	0	3
3		Process Control and Automation	3	0	0	3
4		Machine Learning in Process Engineering	3	0	0	3
5		Advanced Chemical Engineering Thermodynamics	3	0	0	3
6		Chemical Engineering Lab	0	0	3	2
7		Seminar	0	0	2	2
Total			**15**	**0**	**5**	**19**

Semester - II

S. No.	Course Code	Course Title	Components			
			L	T	P	C
1		Chemical Reactor Design	3	0	0	3
2		Elective I	3	0	0	3
3		Elective II	3	0	0	3
4		Elective III	3	0	0	3
5		Elective IV	3	0	0	3
6		Process Simulation Lab	0	0	3	2
7		Comprehensive Viva	0	0	0	2
Total			**15**	**0**	**3**	**19**

Semester - III

S. No.	Course Code	Course Title	Components			
			L	T	P	C
1		Dissertation-I	0	0	0	18
Total			**0**	**0**	**0**	**18**

Semester - IV

S. No.	Course Code	Course Title	Components			
			L	T	P	C
1		Dissertation-II	0	0	0	20
Total			**0**	**0**	**0**	**20**

Electives

Course code	Course Title
	Multiphase Flow
	Process Optimization
	Advanced Separations
	Solar Energy, Photovoltaic Energy
	Waste to Energy Conversion
	Interfacial Science
	Surface Engineering
	Process Intensification
	Energy Storage and Conversion Devices
	Heterogeneous Catalysis Science and Technology
	Computational Fluid Dynamics
	Bio Energy
	Wastewater Management
	Process Modeling and Simulation
	Analytical Techniques
	Petroleum Refinery Engineering
	Air Pollution Control

M.Tech Course – Detailed Syllabus

Semester I

Course Code:	MATHEMATICAL METHODS IN CHEMICAL ENGINEERING	Credits 3-0-0: 3

Pre-Requisites: Course on Engineering Mathematics at Undergraduate Level

Objective:

This course is designed to impart knowledge of advanced mathematical techniques applicable for solving Chemical Engineering problems.

Course Outcomes:

At the end of the course, the student will be able to

1. Formulate and solve eigenvalue problems and their stability aspects.
2. Understand and solve homogeneous and non-homogeneous partial differential equations analytically.
3. Appreciate the approximations in various transport equations and solve using similarity/ integral method

Syllabus:

Introduction of vector space metric, norm, inner product, onto, into, one to one function, completeness of space. Linear combination of vectors, dependent/independent vectors, orthogonal and orthonormal vectors, gram-schmidt orthogonalization. Matrix, determinants and properties.
Eigenvalue problem: Various theorems; solution of a set of algebraic equations; solution of a set of ordinary differential equations; solution of a set of nonhomogeneous first order ordinary differential equations (ivps), applications of eigenvalue problems: stability analysis; bifurcation theory
Differential Equations: Classification of equations; Boundary conditions; Principle of Linear superposition, Special ODEs and Adjoint operators: Properties of adjoint operator; Sturm Liouville theorem for eigenvalues and eigenfunctions.
Solution of linear, homogeneous PDEs by separation of variables: Cartesian coordinate system & different classes of PDEs; cylindrical coordinate system; spherical coordinate system; Solution of PDEs by different methods, Solution of PDEs by Similarity solution method, Solution of PDEs by Integral method

Transformations: Solution of PDEs by Laplace transformation, Solution of PDEs by Fourier transformation

Applications to different chemical engineering processes.

Text books:

1. Mathematical Methods in Chemical Engineering by S. Pushpavanam, Prentice Hall of India, 1998.
2. Applied Mathematics in Chemical Engineering by Norman W. Loney, CRC Press, 2016.

Reference books:

1. Applied Mathematics and Modeling for Chemical Engineers by R. G. Rice & D. D. Do, Wiley, 1995.

Course Code:	ADVANCED TRANSPORT PHENOMENA	Credits 3-0-0: 3

Pre-Requisites: Courses on Momentum, Heat and Mass Transfer at Undergraduate Level

Objective:

The objective of this course is to cover advanced topics in this area like the transport of momentum, heat and mass in turbulent flow, creeping flows, flow through porous media, flow over flat plates and curved surfaces, interphase transport, etc. A balanced overview and fundamental equations for transport processes would be provided along with illustrations regarding solving relevant problems.

Course Outcomes:

At the end of the course, the student will be able to

1. Apply the shell balance approach to derive differential mass and heat balance equations in Cartesian, cylindrical, and spherical coordinates
2. Apply the generalized differential mass and heat balance equations and the Navier-Stokes equations to analyze transport problems
3. Analyze transport problems in simple geometries and derive analytically the concentration, temperature or velocity distribution
4. Analyze transport problems in complex geometries and calculate numerically the concentration, temperature, or velocity distribution using a simulation software
5. Apply the concept of transfer coefficients to describe mass and heat transfer across interfaces

Syllabus:

1. Review of vectors and tensors; Review of basic transport processes; Phenomenological theory – introduction, Eulerian and Lagrangian approaches, equations of integral and differential forms.
2. Reynolds transport theorem; Constitutive relations – Newtonian and non–Newtonian fluids; Momentum transfer – Laminar and turbulent velocity profiles, shear stress and pressure drop in steady, Navier Stokes equations, time smoothed equations for turbulent flow.
3. Fundamentals of boundary layer theory – on flat plate and on an obstacle, turbulent boundary layer, exact solutions of the boundary layer equations for various flows.
4. Heat transfer – temperature profiles in laminar and turbulent flows, Graetz problem, conduction profiles in solids, steady and unsteady free convection, thermal boundary layers – equations for temperature field; time smoothed equations and analogy with momentum transfer.
5. Shell balances of mass species diffusion under various driving forces, diffusion with chemical reaction, convective diffusion in dilute solutions, integral balances in momentum, heat and Mass Transfer.
6. Concentration Distributions in Solids/Laminar Flow; Equations of Change Multicomponent Systems, Concentration Distributions under multiple variable

Text Books

1. Bird,R.B., Stewart, W.E. and Lightfoot, E.W. Transport Phenomena Wiley 1994.

2. Robert S.Brodkey, Harry.C.Hershey. Transport Phenomena-A unified approach McGraw Hill Int.Ed.1988.

3. John C.Slattery, Advanced Transport Phenomena, Cambridge University Press -1999.

Course Code:	PROCESS CONTROL AND AUTOMATION	Credits 3-0-0: 3

Pre-Requisites: Course on Process Control at Undergraduate Level

Objective: This course is intended to provide a comprehensive knowledge of different control schemes for efficient operation of chemical processes. Practical implementation through PLC and DCS will also be taught.

Course Outcomes:

At the end of the course, the student will be able to
1. Design regulatory control scheme for a given process
2. Analyze multivariable processes
3. Apply linear and nonlinear model predictive control
4. Understand PLC and DCS.

Syllabus:

- Introduction to control - Hierarchy of control layers, review of basics. System linearization; state space and transfer function models. PID controller design methods.
- Advanced regulatory control schemes - Cascade control, feed-forward control, ratio control, split-range control, time delay compensator, and inverse response compensator.
- Multivariable control - Challenges; Control pairing; Interactions in closed-loop systems; Relative Gain Array (RGA) and variants. Centralized, decentralized, decoupled control schemes. Directionality.
- Model Predictive Control (MPC) - Concepts; Theory and implementation; Relation with LQ-control. Implementation of MPC, State update and model prediction. Receding Horizon implementation; Issues and Challenges.
- Introduction, Data loggers, Data Acquisition Systems (DAS), Supervisory Control and Data Acquisition Systems (SCADA), Piping and Instrumentation Diagrams (P&ID).
- Programmable logic controller (PLC) – overview, General PLC programming procedures, Introduction to Distributed control systems (DCS).

Text Books:

1. Process Dynamics and Control, Seborg, D. E., Edgar, T. F., Millechamp, D. A., Doyle III, F. J., Wiley, 2014, 3rd Edition.

2. Process Control Fundamentals: Analysis, Design, Assessment, and Diagnosis, Raghunathan Rengaswamy, Babji Srinivasan, Nirav Pravinbhai Bhatt, CRC Press, 2020.

3. Model Predictive Control System Design and Implementation using MATLAB, Liuping Wang, Springer, 2009.

4. Industrial Automation using PLC, SCADA and DCS, Jamkar, R. G., Global press,

2018.

Reference Books:

1. Predictive Control for Linear and Hybrid Systems, Francesco Borrelli, Alberto Bemporad, Manfred Morari, Cambridge University Press, 2017.

2. Process Control: Theory and Applications, Jean-Pierre Corriou, Springer, 2018, Second Edition.
3. Process Dynamics and Control, B. Roffel and B. Betlem, Wiley, 2006.
4. Introduction to Programmable logic controller, Dunning, G. A., Cengage Learning, 2005.

Course Code:	CHEMICAL ENGINEERING LAB	Credits 0-0-3: 2

Pre-Requisites: Basic knowledge in Chemical engineering

Objective:

The objective of the course is to provide insight into the basic tasks, methods and tools in chemical engineering by laboratory experiments.

Course Outcomes:

At the end of the course, the student will be able to acquire practical experience in the application of the knowledge and the methods that are taught in the lectures and tutorials and improve their ability to solve typical problems in chemical engineering and to systematically tackle complex tasks in small groups.

Syllabus: Any ten experiments from the following list will be conducted. The results of the experiments have to be documented during the experiments.

1) Control of Level by using IoT-Based Cascade Configuration

2) Dynamics and Control of level in a Three tank process

3) Control of Level in a non-linear hybrid tank process

4) Performance Study of a Computer-Controlled Recycle Bed Reactor

5) Dynamic Study of a Computer-Controlled Trickle Bed Reactor System

6) Measurement of Pressure Drop in Two-Phase (Gas-Liquid) Flow

7) Study of Ion Exchange Process

8) Operation and Performance Study of a Humidification–Dehumidification Column

9) Mass Transfer Studies in a Packed Bed Adsorption Column

10) Study of Heat Transfer in Vertical and Horizontal Condensers

11) Determination of Absorbance and Concentration using UV–Visible Spectrophotometry

12) Identification of Functional Groups using FTIR Spectrophotometer

13) Experimental Study of Atomic Absorption Spectrophotometer for Trace Metal Analysis

14) Experimental Study of Material Characterization using X-Ray Diffraction

15) Study of High-Performance Liquid Chromatography (HPLC) System

16) Determination of Total Organic Carbon in Water Samples

17) Heat Transfer Studies in Free and Forced Convection using Computer-Controlled Setup

18) Experimental Study of Anion and Cation Analysis using Ion Chromatography

Course Code:	**ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS**	**Credits** **3-0-0: 3**

Pre-Requisites: Course on Chemical Engineering Thermodynamics at Undergraduate Level

Objective: This course aims at providing thorough knowledge of classical and mixture thermodynamics with specific applications and introduces basic concepts of statistical thermodynamics and quantum mechanics.

Course outcomes:

At the end of the course, the student will be able to

1. Apply classical thermodynamics principles for real fluids
2. Understand the statistical approach and apply for property estimation
3. Appreciate the molecular perspective of equilibrium states

Review of classical approach: Introduction to thermodynamics and statistical mechanics; Laws of thermodynamics; PVT relations; Legendre transforms of energy; Property estimation; Maxwell relations; Phase equilibrium.

Statistical approach: Microcanonical, canonical and grand-canonical ensembles; Gibb's

entropy formula and Boltzmann entropy formula; Partition functions; Fluctuations and stability; Probability postulate; Ergodic hypothesis, Molecular interactions and force-fields.

Mixture thermodynamics: Partial molal properties; Fugacity; Excess Gibb's free energy and activity coefficients; Using suitable models for property estimation; Equilibrium and stability analysis

Quantum mechanics: Schrödinger Wave equation; Degeneracy; Partition functions; Ideal gas of polyatomic particles; Molecular partition functions; Einstein and Debye theory of perfect crystals.

Text book:

1. Herbert B. Callen, Thermodynamics and an Introduction to Thermostatistics, John Wiley and Sons, 2nd Edition, 1991.

Reference books:

1. David Chandler, "Introduction to modern statistical mechanics", Oxford University Press, 1987.

2. Stanley I. Sandler, Chemical, Biochemical, and Engineering Thermodynamics Wiley, 4th Edition, 2006

Course Code:	**MACHINE LEARNING IN PROCESS ENGINEERING**	**Credits** **3-0-0: 3**

Pre-Requisites: Undergraduate Mathematics

Objective: This course Provides motivation and understanding of the need and importance of Machine Learning in today's world. This course will Impart knowledge about role of machine learning in process engineering

Course Outcomes:

At the end of the course, the student will be able to

1. Demonstrate proficiency with statistical analysis of data
2. Use inferential statistics for decision making
3. Apply supervised learning for classification and regression problems
4. Apply unsupervised learning for clustering

Syllabus:

Introduction to data analytics, Python fundamentals.

Data Quality and Pre-processing: Distance measures, dimensionality reduction, principal

component analysis (PCA).

Descriptive Statistics:

Graphical approach - Frequency tables, relative frequency tables, grouped data, pie chart, bar chart, histograms, ogives, stem and leaf plots, box plots, dot diagram, scatter plots, Pareto diagram.

Measure of Central Tendency and Dispersion - Arithmetic mean, median and mode, variance, standard deviation, quartiles, range, mean absolute deviation, coefficient of variation, Z scores, normal distribution, confidence interval estimation.

Probability Distribution and Inferential Statistics: Random variables, probability distributions, hypothesis testing, single sample test, two sample test, Type I error, Type II error, Analysis of Variance (ANOVA).

Supervised learning: Linear regression, ridge regression, Lasso regression, logistic regression, multiple linear regression, goodness of fit, bias–variance trade off, k-nearest neighbors algorithm, linear discriminant analysis, classification and regression trees and pruning, support vector machines, random forest, Naive Bayes, Introduction to deep learning.

Unsupervised learning: Cluster analysis – K Means, hierarchical, DBSCAN. Applications to different chemical engineering systems.

Text Books:

1. Applied Statistics and Probability for Engineers, Douglas C. Montgomery, George C. Runger, 6th Edition, John Wiley & Sons Inc., 2016.

2. The Elements of Statistical Learning, Trevor Hastie, Robert Tibshirani, Jerome Friedman, 2nd Edition, Springer, 2009.

3. Introduction to Machine Learning, Ethem Alpaydın,3rd Edition, MIT Press, 2014

Reference Books:

1. A General Introduction to Data Analytics, João Mendes Moreira , André C. P. L. F. de Carvalho, Tomáš Horváth, Wiley, 2019.

2. Introduction to Data Mining, Pang-Ning Tan, Michael Steinbach, Anuj Karpatne, Vipin Kumar, 2nd Edition, Pearson, 2019.

Semester II

Course Code:	CHEMICAL REACTOR DESIGN	Credits 3-0-0: 3

Prerequisites: Basics of chemical reaction engineering

Objective:

To learn about reaction kinetics for single, multiple, isothermal, non-isothermal reactions and reactor design procedures

Course Outcomes:

At the end of the course, the student will be able to

1. Able to analyze chemical reactors and reaction systems
2. Design experiments involving chemical reactors, and analyzing and interpreting data
3. Ability to solve problems of mass transfer with reaction in solid catalyzed reactions
4. Design and sizing of industrial scale reactor on the basis of kinetic data obtained at lab scale

Syllabus

Chemical reaction mechanisms and kinetics: Review of reaction kinetics and ideal reactors, stoichiometry, thermodynamics of reacting systems, catalytic reactions, non-catalytic reactions.

Non-isothermal reactors: Isothermal/Non isothermal steady state and Unsteady state operations. Multiple steady state analysis.

Non-ideal reactors: Principles of non-ideal flow, RTD, Models for non-ideal flow patterns, tanks in-series.

Multiphase reactor design: Gas-Solid and Liquid-Solid Catalytic Reactions: Gas-solid reactions, Liquid-solid reactions, Reactors for Biological Waste Treatment. Multiphase reactors, Fluidised bed reactors; Packed Bed Reactors.

Design and Development of Heterogeneous Catalysts: Effects of External diffusion on heterogeneous reactions, Diffusion and reaction in different shape porous catalysts (cylindrical, cubic and spherical), Falsified Kinetics.

Text Books:

1. Levenspiel O, Chemical Reaction Engineering, 3rd Edition, Wiley India (1999)
2. Fogler S H, Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall India (2015).
3. J. M. Smith,Chemical Engineering Kinetics, McGraw Hill 1981.
4. K. R. Westerterp, W. P. M. Van Swaaij and A. A. C. M. Beenackers, Chemical Reactor Design and Operation by Wiley Blackwell 1987.

Reference Books:

5. Schmidt L D, The Engineering of Chemical Reactions, 2nd Edition, Oxford University Press (2005).

6 .Froment G F and Bischoff K B, Chemical Reactor Analysis and Design, 2nd Edition, John Wiley & Sons (1990)

7. Doraiswamy L K and Uner D, Chemical Reaction Engineering: Beyond the Fundamentals, 1st Edition, CRC Press (2013)

Course Code:	PROCESS SIMULATION LAB	Credits 0-0-3: 2

Pre-Requisites: Basics of linear algebra, calculus, numerical techniques, and chemical engineering principles.

Objective: Introduce computational techniques using process simulation softwares such as MATLAB, SIMULINK and ASPEN with unit process and operation examples.

Course Outcomes:

At the end of the course, the student will be able to

1. Code in MATLAB and run & analyze simulations on SIMULINK & ASPEN

2. Solve various chemical engineering model problems by computation techniques

3. Design of unit processes and operations in the chemical industry

Syllabus:

Introduction to computation methods in chemical engineering: Background of matlab, Solving Linear and Nonlinear equations

Application of Calculus and Optimization in chemical engineering: Solving ordinary differential equations and partial differential equations, Regression and Optimization

Introduction to MATLAB Simulink: Block diagram construction and simulation of

chemical engineering systems

Pure component property analysis and VLE/LLE calculations: Txy-Pxy plots, Computation of VLE data using (i) ideal mixture assumption and (ii) using various activity coefficient models such as Wilson, Van-Laar model, UNIFAC etc.

Unit operations and Unit process calculations by Aspen: Distillation, Heat exchangers, Reactor-separator problems: reflux, recycle ratio, product purity, yield etc

Real case studies: Construction of real chemical industry plant and simulation

Text books:

1. N. Kaisare, Computational techniques for process simulation and analysis using Matlab. CRC Press (2017).
2. Introduction to Chemical Engineering Computing, Second Edition by Bruce A. Finlayson (2006).
3. Numerical Methods for Engineers 7th Edition by Steven C. Chapra and Raymond P. Canale (2015).

Reference books:

1. S.K. Gupta, Numerical Methods for Engineers. New Age International Publishers (2015).
2. R.G.E. Franks, Modeling and simulation in chemical engineering, Wiley Blackwell (1972).
3. Kamal I. M. Al-Malah Aspen Plus: Chemical Engineering Applications, Wiley (2016).

Electives

Electives - I, II & III

Course Code:	MULTIPHASE FLOW	Credits 3-0-0: 3

Objective

Make the student familiar with the effects of bubbles, droplets or solid particles on the flow of a liquid in nature and industrial processes.

Course Outcomes:

At the end of the course the student should know how to classify the various different multiphase flows and know how to determine which mechanisms are at play for various different conditions which occur in natural processes and industry.

Syllabus:

1. Introduction to multiphase flow, types and applications, Common terminologies, flow patterns and flow pattern maps,
2. Flow past immersed bodies: Drag and drag coefficients, flow through beds of solids, motion of particles through fluids, fluidization, types of fluidization and applications.
3. Two-phase flow: Hydrodynamics of Gas-liquid flow, Two–phase flow through pipes. Interaction of fluids: Mixing of a single fluid; degree of segregation, early and late mixing of fluids, models for partial segregation, mixing of two miscible fluids. Gas-liquid flow phenomenon
4. Multiphase Interactions: Drag, lift, virtual mass force, Basset force, one way, two way, three-way and four-way coupling and mathematical formulation of the same.
5. Modelling Methods for Multiphase Flows: Mixture Model, Euler-Euler Model and Euler-Lagrangian Model
6. Multiphase Reactors: Bubble Column, Packed Bed, Fluidized Bed
7. Measurement Techniques used in Multiphase Flows

Text books:

1. One dimensional Two Phase Flow by G. B. Wallis.

2. Measurement of Two Phase Flow Parameters by G.F.Hewitt.

3. Flow of Complex Mixtures by Govier and Aziz.

4. Two Phase Flow by Butterworth and Hewitt.

5. Handbook of Multiphase systems by Hetsroni.

Course Code:	PROCESS OPTIMIZATION	Credits 3-0-0: 3

Pre-Requisites: Mathematics

Objective: Provide in-depth knowledge of various techniques of optimization and their application to chemical processes

Course Outcomes:

At the end of the course, the student will be able to

1. Formulate objective function for a given problem
2. Solve unconstrained single and multi-variable optimization problems
3. Apply linear programming and nonlinear programming techniques
4. Apply optimization methods on chemical and biochemical processes

Syllabus:

Introduction to Optimization (Statement of optimization problems, Classification of optimization problems, Examples from engineering applications, Review of linear algebra); Optimization Problem Formulation (Models for optimization, Optimization problems in chemical/biochemical engineering)

Basic Concepts of Optimization – I (Continuity of functions, Unimodal and multimodal functions, Optimality criteria for unconstrained single variable functions)
Basic Concepts of Optimization – II (Optimality criteria for unconstrained multivariable functions, Equality constrained problems, Lagrange multipliers, Kuhn Tucker conditions)

Unconstrained Single Variable Optimization: Methods and Applications (Region elimination methods, Methods requiring derivatives: Newton-Raphson method, Bisection method, Secant method)

Unconstrained Multivariable Optimization: Direct Search Methods (Simplex method, Hooke-Jeeves pattern search method, Powell's conjugate direction method)
Unconstrained Multivariable Optimization: Gradient Based Methods (Cauchy's method, Newton's method, Marquardt method)

Introduction to Linear Programming (Formulation of linear programming models, Graphical solution, Linear programs in standard form)
Linear Programming: The Simplex Method (Simplex method, Use of artificial variables, Two phase method)
Constrained Nonlinear Programming (Penalty function method, Lagrange multiplier method)
Applications of Optimization (Optimization of various chemical and biochemical processes) (MATLAB)

Text Books:

1. Optimization of Chemical Processes – T. F. Edgar, D. M.Himmelblau and L. S. Lasdon, 2nd Edition, McGraw Hill, 2001.
2. Engineering Optimization: Methods and Applications - A. Ravindran, K. M. Ragsdell, G. V. Reklaitis, 2nd Edition, Wiley India, 2006.,
3. Engineering Optimization: Theory and Practice - S. S. Rao, 4th Edition, John Wiley & Sons, Inc, 2009.
4. Optimization: Theory and Practice, Mohan C. Joshi and Kannan M. Moudgalya, Alpha Science International Limited, 2004.
5. Convex optimization, Stephen Boyd, Lieven Vandenberghe, Cambridge University Press, 2004.
6. Applied Optimization with MATLAB Programming, Venkataraman P., Wiley, 2009, 2nd Edition.

Course Code:	ADVANCED SEPARATIONS	Credits 3-0-0: 3

Pre-Requisites: Basic knowledge in Mass Transfer and Transport phenomena

Objective:

To impart understanding of various aspects of novel separation systems considering application, theory and design. Learn to develop design equations for various filtration processes.

Course Outcomes:

At the end of the course, the student will be able to

1. Evaluate the design parameters for multicomponent distillation process

2. Identify and model suitable membrane process for treatment of target contaminants

3. Understand specific applications of novel separation process

Syllabus:

1. **Advanced Distillation Processes:** Review of Distillation; Steam Distillation; Complex Distillation Processes; Azeotropic Distillation; Homogeneous and Heterogeneous Systems; Pressure Swing distillation; Extractive Distillation with Entrainers; Multicomponent Distillation: Approximate method, Rate Based Method, Equation Tearing Procedure.
2. **Membranes separation processes for gas mixtures:** Membrane Structures, Transport across membranes, Different configurations of membranes, Modeling aspects: product purity and yield;
3. **Membranes separation processes for liquids:** Microfiltration, ultrafiltration, Nanofiltration, Cross-flow, Batch Cell, Module design. Introduction, Theory, Design of Dialysis, Liquid Membranes, Pervaporation and Reverse Osmosis.
4. **Other Separation Processes**: Adsorption (PSA, TSA, advanced processes, modeling), Ion Exchange, Chromatography; Centrifugal separation, Electrophoretic separation, Micellar enhanced separation.

Text Books:

1. J. D. Seader and E.J. Henley, Separation Process Principles, Wiley (2006).

2. R.W. Baker, Membrane Technology and Applications, Second Edition, Wiley (2004).

Reference Books:

1. Charles Holland, Fundamentals of Multicomponent Distillation, McGraw Hill (1997)

Course Code:	SOLAR ENERGY, PHOTOVOLTAIC ENERGY	Credits 3-0-0: 3

Objective: The course provides a thorough understanding of different aspects of solar energy and also photovoltaic cells and their applications.

Syllabus:
Introduction; Nature and availability of solar energy; Principle of operation of solar cells-materials and processing, thin film, unconventional materials and systems; Concentrators; Cells and system characteristics; Power conditioning, energy storage, and grid connection; Maximum power point tracking, PV to grid – single and three phases; Economy and Life cycle costing.
Solar thermal energy.
Water pumping: dc and ac pump drive; Peltier refrigeration.

Text/Reference Books:
1. Hans S. Rauschenbach, Solar Cell Array Design Handbook: The Principles and Technology of
Photovoltaic Energy Conversion. Springer (2013).
2. C. Hu and R.M. White, Solar Cells: From Basic to Advanced Systems. McGraw Hill (1983)

Course Code:	WASTE TO ENERGY CONVERSION	Credits 3-0-0: 3

Pre-Requisites: Basic of heat, thermodynamics, and chemical reaction engineering, Biochemical processes

Objective: The course provides a thorough understanding of waste to energy resources, technologies and systems to convert the waste into energy (e.g., anaerobic digestion, fermentation, pyrolysis, gasification, incineration, etc.). It also provides a basic understanding of the principles underlying the modern design and operation of systems based on recent research.

Course Outcomes:

1. Understand and learn the fundamental aspects involved during the conversion of waste into energy (e.g., anaerobic digestion, fermentation, pyrolysis, gasification, incineration, etc.).
2. Be familiar with the current research scenario associated with biochemical and thermal treatment of wastes & biomass.
3. Acquired skills will be useful in the preparation, planning, and implementation of energy projects.

Syllabus:

1. **Introduction to energy from waste:** Characterisation and classification of waste as fuel agro-based, forest residues, industrial waste, municipal solid waste.
2. **Waste to energy options**: Biochemical and Thermochemical routes; Biochemical Options – Anaerobic Digestion, Fermentation; Thermochemical Options – Pyrolysis, Gasification, and Incineration; Other options – Biodiesel synthesis, Briquetting, Torrefaction, and Hazardous waste management.
3. **Properties of fuels derived from waste to energy technology:** Producer gas, Biogas, Ethanol, and Briquettes, Comparison of properties with conventional fuels.
4. **Other alternate option and Heat and mass balance:** Energy production from waste plastics, Cultivation of algal biomass from wastewater and its application in energy production. Calculations: heat & mass balances
5. **Landfills:** Gas generation and collection in landfills, Introduction to transfer stations.

Text Books:

1. M.M. EL-Halwagi, Biogas Technology, transfer and diffusion, Elsevier Applied science Publisher, New York (1984).
2. D.O. Hall and R.P. Overeed, Biomass-Renewable Energy, John Willy and Sons, New York (1987).
3. J.H. Harker, and J.R. Backhusrt, Fuel and Energy, Academic Press Inc
4. M.J. Rogoff, and F. Screve, Waste-to-Energy: Technologies and Project Implementation, Elsevier Store.

Course Code:	INTERFACIAL SCIENCE	Credits 3-0-0: 3

Pre-Requisites: Fundamentals of Fluid flow and transport processes

Objective: This course will introduce the origin and significance of interfacial interactions and their applications that includes drop dynamics, capillary action and colloidal stability.

Course outcomes:

At the end of the course, the student will be able to

1. Understand the effects of surface forces and their significance
2. Modeling aspects of surface forces and hydrodynamics
3. Understand colloidal stability and its implications

Intermolecular and surface forces: Introduction; van der Waals forces; Electrostatic double layer force; Disjoining pressure; DLVO theory

Two-phase flow: Introduction; Definition of surface tension and its scaling, Young's law and its relevant applications on bubbles and drops, Stress boundary conditions, Marangoni flows highlighting thermocapillary stresses, Thermocapillary migration of bubbles and drops and its applications. Dynamics of hollow drops: upcoming area of research.

Engineering of interfaces: Occurrence of interfaces in science and engineering; Overview of industrial applications of various interfacial phenomena.

Colloidal materials: Properties of colloidal systems; Experimental characterization of colloidal dispersions. Hydrodynamics of a free surface, Capillarity, Physical origin of Instability, Wetting and dewetting, Length Scales, Analysis.

Text Books:

1. Stokes, R. J. and Evans, D. F., Fundamentals of Interfacial Engineering, Wiley-VCH, New York, 1997.

Reference Books:

1. Israelachvili, J., Intermolecular and Surface Forces, Academic Press, London, 1992.
2. Edwards, D.A.,Brenner, H. and Wasan, D. T., Interfacial Transport Processes and Rheology,ButterworthHeinemann,Boston, 1990.

Course Code:	SURFACE ENGINEERING	Credits 3-0-0: 3

Objective:

Design and deploy various coatings that meet the needs of individuals and the industries.

Course Outcomes:

At the end of the course:

1. The student will be able to understand: Principles of coating deposition and surface modification methods - Fundamental coating properties and their relationship - Introduction to corrosion and wear protection, and various functionalities obtainable by coatings and surface treatments.

2. Students have comprehensive background for understanding various manufacturing processes of engineering coatings and surface treatments, structure and properties of coatings, and their industrial use in technical applications.

Surface Engineering: Introduction to surface engineering, Scope of surface engineering for different engineering materials, Surface Preparation methods such as Chemical, Electrochemical, Mechanical: Sand Blasting, Shot peening, Shot blasting, Hydro-blasting, Vapor Phase Degreasing etc., Coatings: Classification, Properties and applications of Various Coatings.

Chemical Vapour Deposition: Mechanisms, important reactions involved, Process parameters and applications.

Physical Vapour Deposition: Vacuum Evaporation Deposition, Reactive Evaporation Deposition, Cathodic Arc Evaporation Deposition, Sputtering, Radio Frequency and Pulsed DC sputtering, Sputter Deposition of Nitride Coating, Sulphide Coating

Surface Coating by Wetting: Mechanism of Wetting, Coating on Ceramics by Wetting, Coating of Monolayer Abrasive grain by Wetting

Characterization of Coating: Physical Characterization, Assessment of coating hardness, friction, surface roughness and thickness, Assessment of Adhesion of Coating, Surface chemistry.

Different methods for surface modification: Surface modification by use of directed energy beams, Plasma, Sputtering & Ion Implantation.

Text Books:

1. J. R. Davis-Surface Engineering for Corrosion and Wear Resistance.

2. George J. Rudzki -Surface Finishing Systems. metal and non-metal finishing handbook-guide, Metals Park : ASM, 1983

3. James A. Murphy- Surface Preparation and Finishes for Metal, McGraw-Hill, New York 1971

4. P. G. Sheasby and R. Pinner - Surface treatment and finishing of Aluminium and its alloy,Volume-2, 5th ed., ASM, Metals Park, 1987

5. Surface Engineering Hand Book, edited by Keith Austin, London : Kogan Page, 1998

Course Code:	PROCESS INTENSIFICATION	Credits 3-0-0: 3

Pre-Requisites: B.Tech. in Chemical Engineering

Objectives: Covers the developments in a number of intensified technologies, with particular emphasis on their application in chemical processes. Provide a basic knowledge of chemical engineering principles and process intensification for chemists and engineers who may be unfamiliar with these concepts.

Course outcomes:

At the end of the course, the student will be able to

1. Understand the need for process intensification
2. Understand various process intensification techniques
3. Understand and apply process intensification techniques to chemical processes
4. Understand and apply process intensification based on micro-reactors

Introduction: Introduction to Process Intensification: History, Philosophy and Concept; Mechanisms involved in the process intensification: Intensification by fluid flow process, mixing, Reactive system;

Role of Process intensification in sustainable development: Problems leading to sustainable development: Concept, Issues and Challenges, Strategies in process design; Design Techniques for Process Intensifications: Scales and stages of process intensification, Methods and Tools for Achieving sustainable design, Multi-level Computer aided tools

Process intensification methods: Process integration by cavitation; Process Intensification by monolith reactor; Interfacial area based PI

Process intensification in Chemical process equipment: Process intensification in distillation; Process intensification in extraction; Process intensification by membrane

Micro Process Technology in process intensification: Introduction to microprocess technology, Process Intensification by Microreactors, Hydrodynamics and transport in microchannel based microreactor

Text Books:

1. Kamelia Boodhoo and Adam Harvey. Process Intensification for Green Chemistry Engineering Solutions for Sustainable Chemical Processing, Edited by Kamelia Boodhoo and Adam Harvey , School of Chemical Engineering & Advanced Materials Newcastle University, UK. Willey, 2013.
2. Juan Gabriel Segovia-Hernández, Adrián-Bonilla-Petriciolet Editors, Process Intensification in Chemical Engineering Design Optimization and Control, Springer, 2016.
3. David Reay, Colin Ramshaw, and Adam Harvey, Process Intensification: Engineering for efficiency, sustainability and flexibility, IchemE, 2nd edition, 2013, Elsevier.
4. S. K. Majumder, Hydrodynamics and Transport Processes of Inverse Bubbly Flow, 1st ed. Elsevier, Amsterdam (2016)

Course Code:	ENERGY STORAGE AND CONVERSION DEVICES	Credits 3-0-0: 3

Pre-Requisites: Basics of electrochemistry and transport processes

Objective: This course will provide in-depth knowledge of different types of energy storage devices, design features and performance. It also introduces various aspects of fuel cells (principles, structural features and applications) as alternatives for sustainable developement.

Course outcomes:

At the end of the course, the student will be able to

1. Design battery rating based on power requirement.
2. Understand the advantages and disadvantages of different types of batteries available.
3. Understand the upcoming trends in Fuel cell technology as an alternative energy source.

Introduction: Alternative energy sources and sustainability; Introduction to electrochemical energy storage and conversion; Introduction to Supercapacitors; Introduction to Lead acid and Lithium ion batteries, Introduction to fuel cells, Introduction to bio-electrochemical energy conversion systems

Lead acid batteries: Lead acid batteries: Flat plate and Tubular batteries; Key components and features; Design of power rating and charging current calculations; Testing and performance curves

Lithium-ion batteries: Basic components and characteristics of Lithium ion cells; Introduction to battery bank design; Supercapacitors; Other types of batteries

Fuel cells: Fuel cells: Types of fuel cells; Applications; Polymer electrolyte membrane fuel cells; thermodynamics of fuel cells; Testing and performance curves.

Renewable energy integration and Applications: Solar, wind energy Storage aspects; Introduction to electric based transportation; Other applications of ESS

Text Books:

1. Energy Storage: Fundamentals, Materials and Applications, by Huggins R. A., Springer
2. O'Hayre, R.P.,S. Cha, W. Colella, F.B.Prinz, Fuel Cell Fundamentals, Wiley, NY (2006)

Reference Books:

1. Battery Systems Engineering by C. D. Rahn and C. Wang, Wiley Pub.
2. Bard,A. J. , L. R., Faulkner,Electrochemical Methods, Wiley, N.Y.(2004)
3. Liu, H.,Principles of fuel cells, Taylor & Francis, N.Y. (2006).

Course Code:	HETEROGENEOUS CATALYSIS SCIENCE AND TECHNOLOGY	Credits 3-0-0: 3

Pre-requisites:

Objectives: Heterogeneous catalysis has its wider outreach in fields of chemical engineering especially processes involved in Chemical, Petroleum, Petro-Chemical industries and environmental remediation front. This course is designed to impart the fundamental concepts involving catalytic synthesis, characterization, Kinetic modeling and applications.

Course Outcome:

By the end of this course, the student will be familiar with the concepts of:

1. Different Adsorption isotherms encountered in catalytic processes.
2. Reaction mechanism development for different gas phase reactions using various methodologies
3. Different catalysts synthesis protocols involved in heterogeneous catalysis
4. Different Characterization techniques for effective and intuitive understanding of different catalytic materials
5. Application of heterogeneous catalysis in different Chemical, Petroleum and Petro-Chemical Processes.
6. New age heterogeneous catalysts application to different applications.

Fundamentals of Catalysis: Introduction, Theories of adsorption, Isotherms- Freundlich, Temkin, BET

Kinetics: Reaction mechanism development, rate expression development, Modeling methodologies etc.

Synthesis Procedures for Catalysis: Wetness Impregnation, Incipient Wetness Impregnation, Sol-gel Techniques, Precipitation methods etc., for synthesis of different catalysts.

Characterization techniques for catalysts :X ray Diffraction, XPS, TEM, SEM, STM, Thermal and Other Temperature-Programmed Methods, , ICP, DRIFTS, FTIR, Raman, GCMS, LCMS, Isotope tracking, etc.

Applications of heterogeneous catalysis in Industries: (i) Chemical Industries (ii) Petroleum and Petro-chemicals ,(iii) Environmental Applications,

Catalysis for other applications: Photo catalysis, Nano metal and metal oxide based catalysts

References

1. Vannice, M. A., & Joyce, W. H. (2005). Kinetics of catalytic reactions (Vol. 134). New York: Springer.

2. Misono, M. (2013). Heterogeneous Catalysis of Mixed Oxides. Elsevier Inc.

3. Thomas, J. M., & Thomas, W. J. (2014). Principles and practice of heterogeneous catalysis. John Wiley & Sons

4. Dumesic, J.A. et al. (1993).The Microkinetics of Heterogeneous Catalysis. ACS professional reference book. Wiley

Course Code:	COMPUTATIONAL FLUID DYNAMICS	Credits 3-0-0: 3

Pre-Requisites: Fluid mechanics and basics of Transport phenomenon

Objective: Introduce computational fluid dynamics along with chemical engineering applications and analysis of fluid mechanics related problems

Course Outcomes:

At the end of the course, the student will be able to

1. Apply Finite difference and Finite volume methods in CFD modeling

2.Generate and optimize the mesh

3.Simulate CFD models and analyze the results

Syllabus

Introduction: Introduction to the CFD approach and Illustration of CFD through a worked out example (triangular and square duct)
Derivation of equations governing fluid flow: Eulerian approach, Conservation equations: mass, momentum and heat balance equations, Navier stokes equations, Equations for incompressible flow
Principles of Solution of the Governing Equations: Finite difference and Finite volume Methods, Convergence, Consistency, Error and Stability, Accuracy, Boundary conditions, CFD model formulation
Mesh generation: Overview of mesh generation, Structured and Unstructured mesh, Guideline on mesh quality and design, Mesh refinement and adaptation
Solution Algorithms: Discretization schemes for pressure, momentum and energy equations - Explicit and implicit Schemes, First order upwind scheme, second order upwind scheme, QUICK scheme, SIMPLE, SIMPLER and MAC algorithm, pressure-velocity coupling algorithms, velocity-stream function approach, solution of Navier-Stokes equations.
CFD Solution Procedure: Problem setup – creation of geometry, mesh generation, selection of physics and fluid properties, initialization, solution control and convergence monitoring, results reports and visualization.
Case Studies: Simulation of CFD problems by using Ansys fluent or COMSOL software.

Text books:

1. Ferziger, J., and M. Peric, Computational Methods for Fluid Dynamics, Third Ed., Springer, (2001)
2. Niyogi, P. Chakrabarty, S.K. and Laha, M.K., Introduction to computational fluid dynamics, Pearson education (2006)
3. Pletcher, R. H., Tannehill, J. C., and Anderson, D., Computational Fluid Mechanics and Heat Transfer, CRC, (2011)

Reference books:

1. Versteeg H.K. & Malalsekera W. An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Longman Scientific & Technical, Harlow, Essex, UK.(1995)
2. Anderson J.D. Computational Fluid Dynamics: The Basics with Applications,McGraw-Hill, Inc.(1995)

Course Code:	**BIO ENERGY**	**Credits** **3-0-0: 3**

Introduction to Bioenergy; Current status, merits & demerits. Feedstock,: starch, oilseed, lignocellulogic and algae based, fuel logistics of Biomass, Biological conversion technologies, enzyme hydrolysis, ethanol fermentation, comparisons of fossil fuels and biofuels, Fundamentals of anaerobic digestion, Microbial fuel cells, Bio-refinery, Economic, Social and Ecological Impacts of Bioenergy at Local, National and Global Levels, Life cycle assessment, current and emerging challenges to bioenergy development, Govt policies and standards.

Text Books:

1. Y. Li, and S. K .Khanal, Bio Energy: Principles & Applications:, Wiley-Blackwell 2016.

2. S. Lee, and Y T Shah, Bio Fuels and Bio Energy: Processes and Technologies, CRC Press, 2012

Course Code:	WASTEWATER MANAGEMENT	Credits 3-0-0: 3

Pre-Requisites: Basics of unit operations and processes; Fundamentals of biological processes

Objective: The course provides a thorough understanding of wastewater management to convert the "burden (i.e., wastewater)" into "resources (i.e., clean water, energy, and fertilizer).

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

1. Understand categorisation of wastewater, their sources along with various characterization methods
2. Learn the fundamental aspects of physical, chemical, and biological processes for wastewater treatment
3. Convert the "burden (i.e., wastewater)" into "resources (i.e., clean water, energy, and fertilizer) using wastewater management techniques

Syllabus:

Introduction: Introduction to water and wastewater engineering, Methods for characterizations of wastewater properties.

Wastewater Treatment Processes: Physical, chemical and biological process for wastewater treatment, Primary, secondary and tertiary treatment including suspended growth and attached growth methods.

Advance Oxidations process and sludge treatment: Advanced oxidations process for removal of recalcitrant components in wastewater, nutrient removal, sludge treatment and its removal

Zero discharge techniques and standards: Progress in zero discharge technique, standards and regulations

Case studies: Case studies related to treatment of Industrial and municipal effluents

Text Books:

1. W. Eckenfelder (Jr.) Industrial Water Pollution Control, McGraw Hill 1999.
2. G. Tchobanoglous, .L. Burton, and H.D. Stensel, Wastewater Engineering Treatment and Reuse (Metcalf & Eddy), McGraw Hill 2002.

Reference Books:

1. H.S. Peavy, D. R. Rowe, G. Tchobanoglous, Environmental Engineering, Mcgraw-Hill 1985.
2. A. P. Sincero and G.A. Sincero, Physical-Chemical Treatment of Water and Wastewater, CRC press 2002.

Course Code:	PROCESS MODELING AND SIMULATION	Credits 3-0-0: 3

Pre-Requisites: Engineering Mathematics, Core Chemical Engineering Courses

Objective: This course is intended to learn model development using first principles and data in different chemical engineering processes and also to apply numerical methods for solving mathematical models.

Course Outcomes:

1. At the end of the course, the student will be able to:
2. Apply conservation laws for different chemical engineering processes
3. Analyse ill-conditionality
4. Solve ODEs, PDEs, DAEs
5. Use different software tools for simulation

Syllabus:

Introduction to modeling, a systematic approach to model building, classification of models. Conservation principles, thermodynamic principles of process systems.

Development of steady state and dynamic lumped and distributed parameter models based on first principles. Analysis of ill-conditioned systems.

Development of grey box models. Empirical model building. Statistical model calibration and validation. Population balance models. Examples.

Solution strategies for lumped parameter models. Stiff differential equations. Solution methods for initial value and boundary value problems. Euler's method. R-K method, shooting method, finite difference methods. Solving the problems using *MATLAB/SCILAB*.

Solution strategies for distributed parameter models. Solving parabolic, elliptic and hyperbolic partial differential equations. Finite element and finite volume methods.

Text Books:

1. Chemical Process Modelling and Computer Simulation, Amiya K. Jana, Prentice Hall, 2011, 2nd Edition.
2. Process Modelling and Simulation in Chemical, Biochemical and Environmental Engineering, Ashok Kumar Verma, CRC Press, 2014.
3. Process Modelling, Simulation and control for Chemical Engineers, William L. Luyben, McGraw-Hill Publishing Company, 1996, 2nd Edition.

Reference Books:

1. Mathematical Modelling and Simulation in Chemical Engineering, M. Chidambaram, Cambridge University Press, 2018.
2. Process Modelling and Simulation in Chemical, Biochemical and Environmental Engineering, Ashok Kumar Verma, CRC Press, 2014.
3. Mathematical Modelling: Case Studies, Jim Caldwell, Douglas K. S. Ng, Kluwer Academic Publishers, 2004.

4. Conservation Equations and Modelling of Chemical and Biochemical Processes, Said S. E. H. Elnashaie, Parag Garhyan, Marcel Dekker Publishers, 2003.
5. Process Modelling and Model Analysis, K. M. Hangos and I. T. Cameron, Academic Press, 2001.
6. Chemical Engineering Dynamics, John Ingham, Irving J. Dunn, Elmar Heinzle, J. E. Prenosil, Jonathan B. Snape, Wiley, 2007.

Online Resources:

1. https://nptel.ac.in/courses/103/107/103107096/

Course Code:	ANALYTICAL TECHNIQUES	Credits 3-0-0: 3

Pre-Requisites: None

Objective: The objective of the course is to provide technical prospectus and overview of different analytical techniques for spectroscopic, spectrometric,microscopic, thermal and chromatographic characterization of materials

Course outcome: By the end of the course, the students will be able to,

1. Understand the basics and application of different analytical techniques and instrumentation used in different analytical laboratories for material characterization.
2. Categorically interpret the fundamental properties of the material using spectroscopic, spectrometric,microscopic, thermal and chromatographic characterization instruments

Syllabus:

Spectroscopy: Introduction, Spectroscopy methods: Infrared, UV-Visible, Fluorescence, Nuclear Magnetic Resonance, Atomic Absorption.

Spectrometry: Mass, Matrix-assisted laser desorption/ionization (MALDI)

Microscopy: Introduction, Atomic Force Microscopy, Field Emission Scanning Electron Microscope with EDXS (Energy-dispersive X-ray spectroscopy), Transmission Electron Microscopy, Laser Scanning Confocal Microscopy, Confocal Raman.

Thermal analysis: Differential Scanning Calorimetry, Thermal Gravimetric Analysis

Chromatography: Introduction, Thin-Layer Chromatography, Types of Column Chromatography: Affinity and Ion Exchange, Gel Permeation and HPLC, Gas Chromatography–Mass Spectrometry

Text / Reference Books:

1. Keith Wilson and John Walker, Principles and Techniques of Biochemistry and Molecular

Biology, Cambridge University Press; 8th Edition,Cambridge University Press, (2018)

2. D. A. Skoog and D. M. West, Fundamentals of analytical chemistry, Cengage Publishers; 9th Edition. Cengage Publishers, (2014)

3. G. D. Christian, P. K. Dasgupta and K. A. Schug, Analytical Chemistry, Wiley Publishers; 7th Edition , Wiley, (2013)

4. R. M. Silverstein, F. X. Webster, D. J. Kiemle and D. L. Bryce, Spectrometric Identification of Organic Compounds, Wiley Publishers; 8th Edition, Wiley, (2014)

5. D. B. Williams and C. B. Carter, Transmission electron microscopy-a text book for material science, Springer Publishers; 2nd Edition ,Springer, (2009)

6. Introduction to Polymer Science. Charles E. Carreher. Jr.,4th Edition,CRC Press, (2017)

Course Code:	PETROLEUM REFINERY ENGINEERING	Credits 3-0-0: 3

Objective: The objective of the course is to provide technical prospectus and overview of different processes and unit operations in petroleum refineries to the students.

Course outcome:

At the end of the course, the student will be able to

1. Characterize the crude based on the assay data and interpret different parameters associated with the crude characterization and petroleum products to different unit operations in the refinery
2. Obtain technical information and overview of various unit operations in petroleum refinery with respective feed, products and process parameters of each unit operation in the refinery

Syllabus:

Introduction: Introduction to petroleum refinery and brief overview of different refinery operations. Brief Description of Petroleum refinery in Indian Context.

Characterization of crude oil and refinery products Origin of petroleum crude oil, TBP and other distillation tests, Petroleum products-their properties, specifications and testing – different properties like flash point, fire point, smoke point, aniline point, carbon residue, kinematic viscosity, pour point, freezing point etc. Interpreting crude Assay data

Petroleum refinery distillation: Pre-fractionation and atmospheric distillation of crude. Stabilization of naphtha. Vacuum distillation of RCO.

Reforming of Naphtha: Isomerization, Alkalization and Polymerization

Residue Upgradation processes: Delayed coking process, Vis-breaking, FCC unit.Furfural/Phenol/NMP extraction, Solvent dewaxing, propane deasphalting. Production of lube oil base stock

Hydrotreatment processes in refining: Hydro-Desulfurisation, Hydrofinishing, Hydrocraking, Residual Hydrocracking and Hydrogen Generation unit (HGU)

Refinery equipment and Elements of design of refinery units: furnaces, distillation columns, reactors, pumps, compressors and piping.

Environmental impact of refineries

References/Text books

Text Books:

1. Petroleum Refinery Engineering by W. L. Nelson,4th Edition, McGraw-Hill, (1958)

2. Petroleum Refining, Technology & Economics by J. H. Gray & G. E. Handwerk,5th Edition, CRC Press, (2007)

3. Petroleum Refinery Distillation by R. N. Watkins,2nd Edition, Gulf publishing company,(1979)

4. Modern Petroleum Refining Processes by B. K. B. Rao, 6th Edition, CBS Publishers,(2014)

5. Fundamentals of Petroleum and PetroChemical Engineering by Uttam Ray Chaudhuri, CRC Press,1st Edition,(2011)

Reference Book:

1. The Chemistry & Technology of Petroleum by J. G. Speight, CRC Press, 5th Edition, 2014

Course Code:	AIR POLLUTION CONTROL	Credits 3-0-0: 3

Pre-Requisites: Basics science
Objective: To provide the scientific and technical background of air pollution, its monitoring techniques, transport and dispersion modeling, and air pollution control technologies.

Course outcomes: At the end of the course, the student will be able to:
1. Identify the major sources of air pollution and understand their effects on health and environment.

2. Evaluate the dispersion of air pollutants in the atmosphere and to develop air quality models.
3. Learn the fundamental aspects of sampling techniques for atmospheric and stack pollutants.
4. Choose and design control techniques for particulate and gaseous emissions.

Syllabus:

Introduction: Introduction to principal aspects of air pollution; History of air pollution; Sources of air pollution; Effects of major air pollutants; Current policies, standards and objectives; Air pollution legislation.

Meteorology and air quality modeling: Meteorology as applied to air pollution and dispersion of air pollutants; Atmospheric chemistry, Aerosol behavior; Transport and dispersion modeling. Commercial air quality models (ADMS and USEPA).

Monitoring and control techniques: Monitoring of emissions and air pollutants in ambient air; Engineering control of stationary sources; Modeling and control of emission from road transport and from industrial sources. Selection of control equipments; Process change, fuel change; pollutant removal and disposal of pollutants; Control devices and systems, removal of dry particulate matter, liquid droplets and mist removal, gaseous pollutants and odor removal.

Indoor air pollution: Indoor air pollution; Personal exposure to air pollution.

Economics in air pollution control: Economics and trends in air pollution control.

Text Books

1. H.S. Peavy, D. R. Rowe, G. Tchobanoglous, Environmental Engineering, Mcgraw-Hill (1985).
2. M.N. Rao, H.V.N. Rao, Air Pollution. McGraw Hill, Indian Edition (2017).

Reference

Richard C. Flagan, John H. Seinfeld, Fundamentals of Air Pollution Engineering. Prentice Hall (1988).

30.11.2025

Annexure-7

OFFICE OF THE DEAN (FACULTY AFFAIRS)
INDIAN INSTITUTE OF PETROLEUM AND ENERGY VISAKHAPATNAM

OFFICE NOTE

File Note No.: IIPE/DoFA/2025 dated 16 June, 2025.

Sub: Addition of New Expert Members in the Department-wise Panel of Selection Committees constituted for the recruitment of faculty at IIPE – Reg;

Ref: Department wise list of experts, IIPE Visakhapatnam;

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1. It is to bring your kind notice that the Institute has earlier approved a panel of expert members for the Selection Committees constituted for the recruitment of faculty members at IIPE, Visakhapatnam as approved by the Senate.

2. Now, it is proposed to include additional/new expert members in the existing department-wise panel. The details of the new experts proposed for inclusion are placed herewith for kind perusal.

3. Submitted for approval of the Competent Authority for inclusion of the enclosed list of new expert members in the existing panel of experts, for faculty recruitment at IIPE and the same may also be placed before the Senate for ratification.

Encl.: List of additional expert members (department-wise)

(Dealing Assistant)

Associate Dean (Faculty Affairs):

DD: APPROVED. To be ~~reflected~~ put for in Senate

30.11.2025

Name of the New Expert members for Faculty Selection Committee;

S. No.	Name of Expert	Department	Address	Contact Details	Research Areas
01	Prof. Giridhar Madras, Senior Professor	Chem Engg	Room: A-505, Academic Block A Indian Institute of Technology Hyderabad Kandi-502284, Sangareddy Telangana, India	giridhar@che.iith.ac.in giridhar.madras@gmail.com	Development of Novel Materials for Energy, Environmental Applications, Catalysis, Energy
02	Prof. Amitava Ghosh Professor	Mech Engg	203, Manufacturing Engineering Section, IIT Madras	+91-44-2257-4724 amitava_g@iitm.ac.in	Development of solid-lubricant composite coating, machining with nanocrystalline diamond coating, micro lubrication technology for machining and grinding, high performance metal working fluid, green machining, sustainable solutions to machining challenges, precision joining of cBN and diamond, hybrid grinding of ceramics and composites, micro mechanical machining etc.
03	Dr. V. Reddy	Mech Engg			
04	Prof. P. P. Chakraborthy	Petro Engg	Department of Geology University of Delhi, Chhatra Marg Delhi- 7	9958372502 parthageology@gmail.com	Sedimentology (clastic and carbonate), Sequence Stratigraphy and basin Modeling
05	Prof. Jayant Kumar Tripathi	Petro Engg	School of Environmental Sciences Jawaharlal Nehru University New Delhi 110067, INDIA	jk.trip@yahoo.com jktripathi@mail.jnu.ac.in Mobile: +91-9717112227 Landline: 011-26704311 (Office)	Geochemistry of Earth Surface Processes: River processes geochemistry, Desert processes geochemistry, Chemical Weathering of Rocks, Sediment Geochemistry, Paleoclimatology / Paleolimnology
06	Prof. Pradip Kumar Sadhu	Petro Engg & ES			
07	Prof. Kalyan Chatterjee	Energy Sc. & Engg	Professor Dept. of Electrical Engineering Indian Institute of Technology (ISM), Dhanbad	kalyanchatterjee@iitism.ac.in	Power System, Soft Computing Application In Power System, Renewable Energy

8	Prof. Saurya Singh	H&S – Economics			
09	Prof. Sthanu R Nair	H&S – Economics			
10	Prof. Meera Srinivas, EFLU Hyd	H&S - English	Dept. of Department of Materials Development, Testing and Evaluation, EFLU Hyderabad	Office: +91-40-27689733	English Education, Curriculum development and Language Skills Training and Development
11	Prof. G. Neelakantan, IIT Kanpur	H&S – English	Professor, Department of Humanities and Social Sciences, IIT Kanpur	Email: gn@iitk.ac.in Office Phone: 0512-259-7872	Twentieth and Twenty-First Century American Literature, intersections of literary modernism and postmodernism, Western or Eastern traditions, continue to exercise the contemporary cultural and literary imagination.

30.11.2025