INSTITUTE OF CHEMICAL TECHNOLOGY
Ordinances, Regulations and Syllabi relating to the
Degree of Master of Technology in Green Technology (M. Tech. Green Technology)

1. Introduction

The Institute has revamped its academic structure. All the courses are credit based and the evaluation is grade based. Due to these academic reforms the Regulation R.9, passed by the Senate in its meeting held on 10th May 2007 stands repeal and is replaced by the new Regulation R.9.

Credit system is a systematic way of describing an educational programme by attaching credits to its components. The definition of credits may be based on different parameters, such as student workload, learning outcomes and contact hours. It is a student-centric system based on the **student workload** required to achieve the objectives of a programme. It should facilitate academic recognition of the courses and mobility of the students. Credits assignment is based on the principle that Credits can only be obtained after successful completion of the work required and appropriate assessment of the learning outcomes achieved. As per the AICTE norms 2L/week of lectures are 2 credits, while 2h/week of practicals/tutorials are1 credit. This may be taken as the basis.

Student workload consists of the time required to complete all prescribed learning activities such as attendance at lectures/practicals, seminars, projects, etc. Credits are allocated to all the educational components of a study programme and indicate the quantity of work each component requires to achieve its specific objectives.

Evaluation is an important component of any teaching-learning process. The Institute gives emphasis on continuous evaluation with considerable freedom to the teacher in deciding the mode of evaluation of the students. The performance of the student is documented by a **grade** at the end of the semester. The grading scale ranks the students on a statistical basis. Therefore, statistical data on student performance is a prerequisite for applying the grading system.

2. Course Credits

In general a certain quantum of work measured in terms of **credits** is laid down as the requirement for a particular degree. The student acquires credits by passing courses every semester, the amount of credit associated with a course being dependent upon the number of hours of instruction per week in that course.

There are mainly two types of courses in the Institute - lecture courses and laboratory courses. Lecture courses consist of lecture (L) and tutorial (T) hours. Laboratory courses consist of practical (P) hours. The credit (C) for a course is dependent on the number of hours of instruction per week in that course, as given below:

(1) 1h/week of lecture (L) or tutorial (T) = 1 credit
(2) 2h/week of Practicals (P) = 1 credit
(3) Credit (C) for a theory course = No. of hours of lectures per week + No. of hours of tutorials per week = L + T
(4) Credits (C) for a Laboratory course = ½ x No. of hours of laboratory course per week

Credits will be assigned to In-plant, Seminar, Projects and other mandatory course requirements also and these will be mentioned in the respective syllabi. There may be some non-credit requirements. A student is required to earn credits as mentioned in the syllabus.

3. Evaluation

3.1 The weight ages of different modes of assessments shall be as under.

	In-Semester evaluation		End-Semester-Exam	Components of continuous mode
	Continuous mode	Mid Semester-Exam		
Theory	30%	30%	40%	Quizzes, class tests (open or closed book), home assignments, group assignments, *viva-voce* assignments, discussions
Practicals	50%	-	50%	Attendance, *viva -voce*, journal, assignments, project, experiments, tests

3.2. In-Semester Evaluation:

(a) It is expected that the teacher would conduct at least two assessments under the continuous mode in a Semester.

(b) The teacher will announce at the beginning of the respective course the method of conducting the tests under the continuous mode and the assignment of marks

(c) In-semester performance of all students should be displayed and sent to the academic office by the teacher at least 15 days before the end-semester examination.

(d) For the theory courses, there will be one mid-semester test for each course to be held as per the schedule fixed in the Academic Calendar.

(e) For mid –semester examinations in theory papers, duration of examination will be 1 hour for 3 credit courses and 2 hours for 4 credit courses

3.3. End-Semester examination:

a) The semester end examination will cover the full syllabus of the course and will be conducted as per the Institutional time table at the end of each semester.

b) For end –semester examinations in theory papers, duration of examination will be 1 hour for 3 credit courses and 2 hours for 4 credit courses

3.4 Passes and Fail

(a) The candidates who obtain 40% and more marks of the total marks of a subject head shall be deemed to have **passed** the respective subject head.

(b) The candidates who obtain marks less than 40% of the total marks of a subject head shall be deemed to have **failed** in the respective subject head **(Grade FF).**

3.5 Grades:

(a) The performance of a student shall be documented by a **Letter grade.** Each letter grade has a **Grade point** associated with it. The Grades and Grade points shall be assigned to each head of passing and both will be indicated in the mark-list of the semester examination.

(c) The total marks (in-semester + end-semester) of a candidate in a subject head are converted into a letter grade, based on the relative (and some times the absolute) performance of the student.

Letter Grade	**Grade Point**
AA	10
AB	9
BB	8
BC	7
CC	6.5
CD	6
DD	5.5
EE	5

(d) For granting class a grade point of 6.0 and above will be considered equivalent to First class.

(c) The grades to be allotted in the case of students who fail or do not appear at the end-semester examination shall be as under.

Letter Grade	Grade Point	Explanation
FF	0	The candidate fails in subject head. The candidate will be allowed to take end-semester repeat or subsequent examinations as per rule.
XX		The candidate has not kept term for the subject head due to attendance less than requisite. Further see 3.5(g) below. In the above cases, the candidate has to repeat the respective course by paying the fees.
I	0	The candidate has kept term for the subject head, has taken all the internal examinations with satisfactory performance, but has failed to take the end-semester examination or repeat examination due to genuine reasons. The candidate will be allowed to take end-semester repeat or subsequent examinations as per rule.
FR	0	The candidate has exhausted all the permissible chances to clear the end-semester examinations. The candidate has to register for the respective semester again for all the subject heads or will be out of the respective degree course as per the rules.
DR	0	(i) The candidate hasn't participated in academic programme. (ii) The candidate has taken a drop for the subject head; - provided he/she intimates the same (i or ii) at least 7 days in advance of the commencement of the end-semester examination for the respective year.

(d) Grades **FF** and **I** are place-holders only and do not enter into CPI/SPI calculations directly. These grades get converted to one of the regular grades after the end-semester examination.

(e) A candidate with an **FR** grade is not eligible for any repeat examination in that course and has to re-register for that semester by paying the appropriate fees.

(f) **I** grade will not be continued beyond the permissible number of end-semester/repeat examinations [Refer to current Regulation R.9 (9) and R.9 (10)].In the six consecutive exams conducted by the institute, irrespective of whether the candidate fails to take any of these exams.

(g) **'XX' Grade:** The grade **XX** in a course is awarded if – (i) candidate does not maintain the minimum 75% attendance in the Lecture/Tutorial/Practical classes, (ii) candidate receives less than 20% of the combined marks assigned for continuous assessment and mid-semester examination, and (iii) candidate indulges in a misconduct/uses unfair means in the examination, assignments, etc., of a nature serious enough to invite disciplinary action in the opinion of the teacher.

(**Note:** Award of the **XX** grade in the case of g(iii) above shall be done by Disciplinary Action Committee (DAC)).

(h) The names/roll numbers of students to be awarded the **XX** grade should be communicated by the teacher to the Academic office as per academic calendar before the last date of submission of the application for end-semester examination.

3.6. Awarding the grades

The grading scale ranks the students on a statistical basis on the basis of the overall performance of the students of a given class in the given subject head. Therefore, statistical data on students' performance is a prerequisite for applying the grading system. While assigning grades in a given subject head, it is essential to know the **average marks (AM)** obtained by the students *who have passed the subject head* and the **highest marks (HM)** obtained in the *same subject head.*

3.6.1. If the **average marks (AM)** obtained by the students *who have passed the subject head* is <60%, the interval AM shall be awarded grade CC and the other grades shall be decided as follows:

(i) AA, AB, BB, and BC grades shall be decided between the AM and HM by dividing the range in equal intervals.

(ii) CD, DD and EE grades shall be decided between the AM and minimum marks required for passing the head (i.e. 40%) by dividing the range in equal intervals.

3.6.2. If the **average marks (AM)** obtained by the students *who have passed the subject head* is such that **60% ≤ AM < 70%,** the interval AM shall be awarded grade BC and the other grades shall be decided as follows:

(i) AA, AB, BB grades shall be decided between the AM and HM by dividing the range in equal intervals.

(ii) CC, CD, DD and EE grades shall be decided between the AM and minimum marks required for passing the head (i.e. 40%) by dividing the range in equal intervals.

3.6.3. If the **average marks (AM)** obtained by the students *who have passed the subject head* is **≥ 70%,** the interval AM shall be awarded grade BB and the other grades shall be decided as follows:

(i) AA and AB grades shall be decided between the AM and HM by dividing the range in equal intervals.

(ii) BC CC, CD, DD and EE grades shall be decided between the AM and minimum marks required for passing the head (i.e. 40%) by dividing the range in equal intervals.

4. SPI and CPI

(a) **Semester Performance Index (SPI):** The performance of a student in a semester is indicated by **Semester Performance Index (SPI),** which is a weighted average of the grade points obtained in all the courses taken by the student in the semester and scaled to a maximum of 10. (SPI is to be calculated upto two decimal places.)

A Semester Grade Point Average (SGPA) will be computed for each semester as follows:

$$SGPA = \frac{\left(\sum_{i=1}^{n} c_i g_i\right)}{\left(\sum_{i=1}^{n} c_i\right)}$$

Where

'n' is the number of subjects for the semester,

'c_i' is the number of credits allotted to a particular subject, and

'g_i' is the grade-points awarded to the student for the subject based on his performance as per the above table.

SGPA will be rounded off to the second place of decimal and recorded as such.

(b) **Cumulative Performance Index (CPI):** An up to date assessment of the overall performance of a student from the time he entered the Institute is obtained by calculating **Cumulative Performance Index (CPI)** of a student. The CPI is weighted average of the grade points obtained in all the courses registered by the student since he entered the Institute. CPI is also calculated at the end of every semester (upto two decimal places). .

Starting from the first semester at the end of each semester (S), a Cumulative Grade Point Average (CGPA) will be computed as follows:

$$CGPA = \frac{\left(\sum_{i=1}^{m} c_i g_i\right)}{\left(\sum_{i=1}^{m} c_i\right)}$$

Where

'm' is the total number of subjects from the first semester onwards up to and including the semester S,

'c_i' is the number of credits allotted to a particular subject, and

'g_i' is the grade-points awarded to the student for the subject based on his performance as per the above table.

CGPA will be rounded off to the second place of decimal and recorded as such.

(c) The CGPA, SGPA and the grades obtained in all the subjects in a semester will be communicated to every student at the end of every semester / beginning of the next semester.

(d) **When** a student gets the grade 'FF', or I' in any subject head during a semester, the SGPA and CGPA from that semester onwards will be tentatively calculated, taking only 'zero' grade point for each such 'FF' or 'I' grade. When the 'FF' grade(s) has / have been substituted by better grades after the repeat examination or subsequent semester examination, the SGPA and CGPA will be recomputed and recorded.

5. Repeat End-Semester Examination

5.1. For those candidates who fail in a subject head or are eligible for appearing at the repeat examination, **Repeat End-Semester Examination** will be conducted within one month from the declaration of the results of regular end-semester examination, as per **Regulation R.14**.

5.2. The marks obtained by candidates in the in-semester examinations (continuous assessment and periodic test) will be carried forward in such cases.

5.3. Grading the performance in the Repeat Examination: The grades will be assigned as per 3.5 and 3.6 above. However, for a candidate taking any repeat examination or subsequent regular semester examination or performance improvement examination shall be awarded **one grade lower** than that decided on the basis of the actual marks obtained; provided 'EE' grade obtained in such an examination shall remain 'EE'. For reference see the table below.

Grade obtained in repeat or subsequent end-semester examination	**Grade to be assigned**	**Grade point**
AA	AB	9.0
AB	BB	8.0
BB	BC	7.0
BC	CC	6.5
CC	CD	6.0
CD	DD	5.5
DD	EE	5.0
EE	EE	5.0

5.4. Revaluation of end-semester and repeat examination: Candidate's performance in these examinations will be displayed on proper notice board and after 3 days of such display the marks will be sent to the Academic Office. No revaluation of these examinations will be allowed.

6. Passing of a Semester examination

A candidate shall be declared as **'PASSED'** any semester examination if he/she has
(a) Cleared all heads of passing by securing grades EE or higher in all the heads;
(b) Passed all the heads of passing such as project, seminar, training, etc as per the rules;
(c) Satisfactorily completed all the mandatory requirements of the course;
(d) paid all the Institute dues;
(e) No case of indiscipline pending against him/her.

7. Eligibility for the Award of a Degree

A candidate shall be declared eligible for the award of a degree, if he/she has cleared all the semester examinations as given in (6) above.

8. Allowed to keep terms (ATKT)

8.1 A candidate who has I grade in one or more heads of passing of an odd semester of an academic year shall be allowed to keep terms for the respective even semester.

8.2. A candidate shall be allowed to keep terms for the subsequent academic year if he/she has FF or I grades in not more than two heads of passing from all the heads of passing of the two terms of the previous academic year taken together. Such a candidate shall be declared as **FAILED, ATKT**.

8.3. A candidate who has not cleared Semester-I and II as per clause 6 above shall not be eligible to register for semester-V and VI.

8.4. A candidate who has not cleared Semester-III and IV as per clause 6 above shall not eligible to register for semester-VII and VIII

9. Repeating a course

9.1 A student is required to repeat the course of a subject head under the following situations:
(a) A student who gets an **XX, FR, or DR** grade in a course; or
(b) A student has exhausted all permissible chances to clear the subject head.

9.2 A candidate from second, third and fourth years who remains absent for the regular end-semester examination of a semester and the corresponding repeat examination for **ALL SUBJECTS** shall have to take fresh admission for the corresponding year; unless the candidate has dropped out / terminated from the course.

9.3 If a candidate at the Second, Third or Fourth year fails to pass any semester examination in not more than 4 consecutive examinations, including the repeat examinations, from the date of registering for the respective year, the candidate shall have to take readmission for the corresponding year again in which the failure has occurred, provided the course is not changed.

10. Improvement of performance

A candidate will be allowed to appear at the **entire examination** after the regular end-semester examination as per the respective rules to improve the performance. In such a case if the result of the examination repeated –

1. Is better than the previous one, the previous result shall be declared null and void; and
2. Is worse than the previous one, the result of the subsequent examination shall not be declared.
3. However, awarding of final grade will be made under the provision of sub clause 5.3 above.

11. Exit rules for poorly performing students

A candidate shall be excluded from a course under the following conditions:

(a) If he/she fails to pass any semester examination of the any year of the course in not more than four consecutive attempts (Examination conducted by Institute) from the date of joining the course.

(b) If he/she does not keep two consecutive terms without giving any reasonable justification (as prescribed by the institute) for doing so.

(c) If a candidate fails to fulfill all the requirements of his/her respective degree within the prescribed period from the date of taking admission to the course, the candidate shall be excluded from the course.

12. Miscellaneous

(a) Although CPI will be given in the Semester grade report, the final degree certificate will not mention any **Class** whatsoever.

(c) Not withstanding anything said above if a course is revised /restructured then transient provisions applicable at the time of revision /restructuring shall be applicable.

Syllabus Details for the degree of
Master of Technology in Green Technology Course

No.	Subject	Credit	Hr/Week			Marks			
			L	T	P	Continuous Assessment	Mid-semester Examination	Final Examination	Total
SEMESTER I									
GTT 2001	Fundamentals of Green Chemistry and Technology	3	2	1	0	15	15	20	50
GTT 2002	Fundamentals of Catalytic Science and Engineering	3	2	1	0	15	15	20	50
GTT 2003	Chemical Reaction Engineering	3	2	1	0	15	15	20	50
	Elective - I	3	2	1	0	15	15	20	50
	Elective - II	3	2	1	0	15	15	20	50
GTP 2001	Project I (critical review of one research publication)	3	---	---	3			30 (Report) 20 (Presentation)	50
GTP 2002	Project II (Seminar)	3	---	---	3			30 (Report) 20 (Presentation)	50
	TOTAL:	21	10	5	6				350
SEMESTER II									
GTT 2004	Advances in Separation Processes	3	2	1	0	15	15	20	50
GTT 2005	Modern Instrumental Methods	3	2	1	0	15	15	20	50
GTT 2006	Green Biotechnology	3	2	1	0	15	15	20	50
GTT 2007	Nanotechnology in Green Chemistry	3	2	1	0	15	15	20	50
	Elective III	3	2	1	0	15	15	20	50
	Elective IV	3	2	1	0	15	15	20	50
GTP 2003	Project III (critical literature review of Research Project)	3	---	---	3			30 (Report) 20 (Presentation)	50
	TOTAL:	21	12	6	3				350
SEMESTERS III and IV									
Project evaluation of 200 marks (12 credits) for Sem III and 500 marks (30 credits) for Sem IV.									

SEMESTER I

1.	**GTT 2001 – Fundamentals of Green Chemistry and Technology** Nature of chemicals and world chemical scenario, Prevention, Atom Economy, Less Hazardous Chemical Syntheses, Designing Safer Chemicals, Safer Solvent and Auxiliaries, Design for Energy Efficiency, Use of Renewable Feedstocks, Reduction of Derivatives, Catalysis, Design for Degradation, Real-time Analysis for Pollution Prevention, Inherently Safer Chemistry for Accident Prevention. **Reference books:** Overview of Green Chemistry • James Clark, Green chemistry: Challenges and Opportunities.	45 h
2.	**GTT 2002 – Fundamentals of Catalytic Science and Engineering** Relevance and examples, Homogenous and heterogeneous catalysis, Fundamentals of homogeneous catalysis and mechanisms and kinetics, Fundamentals of adsorption, isotherms, energetics, structural	45 h

	and dynamic considerations, Mechanisms, models and kinetics of surface reactions, Fractal models, Determination of surface structure though modern methods , Significance of Pore structure and models, Solid and surface chemistry of catalysis, Quantum mechanical, molecular mechanical and hybrid models, Acid--base catalysis, Transition metal catalysis. Metal and supported metal catalysis, metal-support interaction, Metal oxides and determination of acidity and basicity, Nature and type of supports , Solid acid catalysis, Solid base catalysis, Catalyst design through artificial intelligence and computer modelling, Poisoning, promotion, deactivation and selectivity. **Reference books:**	
3.	**GTT 2003 – Chemical Reaction Engineering** Types, classification, application of industrial importance. Reactor design, Reactor safety, Hydrodynamic characteristics of different phases in particulate and aggregative fluidized beds, bubble columns, slurry reactors spray columns, loop reactors and mechanically agitated contactors. Estimation of design parameters such as pressure drop, fractional phase hold-up, mass and heat transfer coefficient, extent of mixing, etc. Experimental methods on multiphase reaction engineering. Mathematical modeling. **Reference books:** Chemical Reaction Engineering, O. Levenspiel Elements of Chemical Reaction Engineering, H. Scott Foggler	45 h
4.	**Elective – I (from the list appended)** • Candidate will have to choose one of the elective subjects offered for that semester from the elective subjects. A consolidated list of all the elective subjects is given at the end.	45 h
5.	**Elective – II (from the list appended)** Candidate will have to choose one of the elective subjects offered for that semester from the elective subjects. A consolidated list of all the elective subjects is given at the end.	45 h
6.	**GTP 2001 – Project I (critical review of one research publication)** **INSTRUCTIONS FOR CANDIDATES** In this project, the candidate is expected to review single research publication either published or manuscript in preparation as decided by the faculty advisor. In general a written report on similar guidelines as given for project II later needs to be submitted but the distribution of the content should be as follows: **(a)** 5% weightage (1 page) should be given to important features of the paper in own words of the candidate. **(b)** 45% weightage should be given to literature survey including significance of the area of research discussed in the paper. **(c)** Remaining part should focus on the detailed analysis of the paper. Some general guidelines for the critical analysis of a research publication include: **ORIGINALITY (5 marks):** Are the facts and ideas new, or have they been covered before by this author or other authors? Is there enough useful information to warrant this paper and whether the length of the paper is justified? If you feel the material is not new, please cite references in which it has already been reported. **TECHNICALLY CORRECT (20 marks):** Is the paper technically correct; are assumptions reasonable; is the reasoning logical? If you think it is not, specify what you think is incorrect and suggest the correct approach. Are the methods used in the work appropriate? Are there any internal contradictions or computational errors and are there any loopholes in the observations? If so, please explain. **CLARITY (5 marks):** Is the paper reasonably easy to follow and understand, complete but not verbose, and does it stick to the subject? If not, please comment. **BIBLIOGRAPHY (5 marks):** Does the author cite all the references in the text and vice versa? Are the references complete and as per guidelines? Does the manuscript accurately represent statements in cited references and do not reproduce? **TITLE/ABSTRACT (5 marks):** Is the title suitable and adequate? Does the Abstract (normally 50-150 words) bring out the main points of the paper? **ILLUSTRATIONS AND TABLES (5 marks):** Is there material that could be better covered in a table? Is there needless duplication between text illustrations and tables? Are there too many illustrations or tables? Are the illustrations clear and legible? Are the experiments/results & discussion/illustrations/tables same/similar to other papers in similar area? **ALTERNATIVE INTERPRETATIONS (5 marks):** Are there other valid interpretations of the observations? If so, please elaborate.	45 h
7.	**GTP 2002 – Project II (Seminar)** The Seminar work is concerned with a detailed and critical review of an area of interest to Chemical Engineering. Typically, the report should contain and will be evaluated based on the following	45 h

points:

(a) Introduction: 2 pages maximum,

(b) Exhaustive review of literature (including figures): 10 – 12 pages: 50% Weightage

(c) Critical analysis of the literature and comments on the analysis Critical analysis should also contain quantitative comparison of observations, results, and conclusion amongst the various papers.

2. Two typed copies of the report on thesis size bond paper (297 mm x 210 mm) are to be submitted to Coordinator on **time to be decided by the coordinator.** The detailed timetable for the presentation would be communicated.

3. The report should be prepared using the Times Roman font (size 12) using 1 1/2 spacing leaving 1-inch margin on all sides producing approximately 29 lines per page. The report should be typed on one side of the paper and need not be bound in a hard cover binding. Figures and tables should be shown as a part of the running text. Each figure should be drawn inside a rectangular box of 12 cm width and 10 cm height. The figures must be sufficiently clear and hand drawn figures will be acceptable. Particular care must be taken if a figure is photocopied from source. Each figure must have a sequence number and caption below. Each table must have a sequence number and title at the top.

4. Name of the student, title of the problem and year of examination must be indicated on the top cover. THE NAME OF THE SUPERVISOR (ONLY INITIALS) MUST APPEAR ON THE BOTTOM RIGHT CORNER OF THE TOP COVER.

5. The report must be precise. All important aspects of the topic should be considered and reported. **The total number of pages, including tables, figures, and references should not exceed 30.** Chapters or subsections need not be started on new pages, while getting the report typed.

6. Typographical errors in the report must be corrected by the student. The student will be discredited for any omission in the report. All the symbols used in the text should be arranged in an alphabetical order and given separately after conclusions.

7. The list of references should be arranged in alphabetical order of the names of authors. In the text, the reference should be cited with author's name and year. (author - date style) For example:

(i) The flow pattern in gas-liquid-solid fluidized bed has been reported in the published literature (Murooka et al., 1982).

OR

(ii) Murooka et al. (1982) have measured flow patterns in gas-liquid-solid fluidized beds. The title of the article should also be included. The references must be given in the following standard format.

(a) Format for listing references of articles from periodicals: Murooka S., Uchida K. and Kato Y., Recirculation Turbulent Flow of Liquid in Gas-Liquid-Solid Fluidised Bed", J. Chem. Engg. Japan, 15, 29-34 (1982).

(b) Format for listing references of Books:
Constant R.F.,"Crystallization, Academic Press, New York, pp. 89-90, 1968.

(c) Format for listing Thesis:
Niranjan K., "Hydrodynamic and Mass Transfer Characteristics of Packed Columns", Ph.D. (Tech.) Thesis, University of Mumbai, 1983.

(d) Format for listing references of Patents in Chemical Abstracts:
Cananaush R.M., U.S.Patent 2,647,141, Cf. C.A. 48, 82636 (1954).

(e) Format for listing Handbooks, Tables, Symposia etc.:
Kumar R and Kuloor N.R., "Formation of Drops and Bubbles", in Advances in Chemical Engineering, Vol.8, T.B. Drew et.al. (Eds.) New York, Academic Press, pp.256-364 (1970).

(f) Format for listing Private Communications and other categories:
Sharma, M.M., Private Communication (1984).

8. Consistency of units should be maintained in the written report. SI systems should be used. [For SI system - Ref: Ind. Chem. Engr., 24, 32, 3 (1983)]. Units used in the literature (if not SI) should be correctly converted.

9. The time allotted for the oral presentation of seminar is 20 minutes: additional 10 minutes are provided for questions and answers.

10. INCOMPLETE AND CARELESSLY WRITTEN REPORT IS LIABLE TO BE REJECTED.

11. The last date for submission will NOT be extended on any grounds whatsoever.

12. There must not be any acknowledgment about the guidance by the faculty in the Seminar.

13. The Seminar will be evaluated on the basis of (i) rational approach to the problem, ii) correctness and completeness of the written text and iii) performance in the oral presentation.

	14. Word-to-word copying from the published article is not permitted. Flowery language is not to be used.	

SEMESTER II

8.	**GTT 2004 – Advances in Separation Processes** Selection of separation process. The chemistry of adsorption. Adsorbents. Equilibria. Yield and Purity. Batch adsorption. Kinetic analysis. Discrete stage analysis. Adsorption in fixed beds. Design and scale-up of adsorption and chromatography equipment. Reactive distillation, Principle of separations through membranes. Micro filtration. Ultrafiltration. Reverse Osmosis. Pervaporation. Selection of membranes. Mechanism of fouling. Design and scale-up of membrane equipment. Electrophoresis. Electro dialysis and isoelectric focusing. Chemical, physical and biochemical aspects of isolation and purification of biomolecules. Product release from a cell. Concentration and separation methods: membrane, ion exchange. Precipitation and extraction. Chromatographic methods of purification. Design of downstream processing equipment. Downstream process economics. **Reference books:** Transport Processes and Separation Process Principles, C.J. Geankoplis Separation Processes, C.J. King Separation Process Principles, Authors: J.D. Seader, E.J. Henley	45 h
9.	**GTT 2005 – Modern Instrumental Methods** Fourier Transform Infrared Spectroscopy: Molecular Vibrations, Frequency shifts associated with structural changes; Basic theory of FTIR spectroscopy, interferogram, digitization of interferogram, data points collection; Instrumentation and advantages of FTIR spectrophotometry; Qualitative and quantitative analysis using infrared spectrophotometry. Ultraviolet and Visible Spectrophotometry: Electronic transition, spectrum, shift of bands with solvents, isolated double bonds, conjugated dienes, carbonyl compounds, aromatic and heteroaromatic compounds; Application in pollution control and chemical industry. Nuclear Magnetic Resonance: Basic principle of NMR phenomenon, relaxation processes, spin-spin interaction, chemical shifts, interpretation of NMR spectra, correlation-hydrogen bonds to carbon and other nuclei; nstrumentation-Continuous and pulsed NMR, carbon-13NMR. X-ray Diffraction: Crystal geometry and structural determination; Bragg law of X-ray diffraction, powder method ; X-ray spectrometers-wide and small angle diffractometers; Chemical analysis by X-ray diffraction. Particle Size Analysis: Particle size, sampling, conventional techniques of particle size measurement, light scattering, particle size measurement by light scattering techniques; Dynamic light scattering (DLS), fiber optic dynamic light scattering (FDLS). Chromatography: Basic theory of separation, efficiency, resolution; Liquid chromatography, high performances liquid chromatography; Gas chromatography-columns and detectors; Qualitative and quantitative analysis. Mass Spectroscopy: Basic principle, ionization of a molecule on electron impact, fragmentation processes in organic compounds, interpretation of mass spectra, molecular weight, molecular formula; Instrumentation-different types of ionization sources and magnetic analyzer. **Reference books:**	45 h
10.	**GTT 2006 – Green Biotechnology** Biotechnology, Applications of green concepts in biotechnology Biochemistry and microbiology, Enzymatic reactions, Supported Enzyme Catalysis , Enzyme engineering, enzyme modifications, stability, reactivity and selectivity considerations, Genetics and Genetic engineering, DNA recombinant technology, Hybridoma technology, single cell proteins, gene manufacturing, Fermentation and design of fermenters with modified organisms Bioprocess simulations, molecular modelling for protein synthesis and drug design, protein engineering, Applications in fermentation industry, pharmaceutical industry, medical field such as gene therapy, Biomedical engineering, Bioreactor design, Scale up of bioreactions/reactors, Downstream processing in biochemical industry, Organic synthesis using supported microbes and enzymes. Biopharmaceuticals, biorefinery and biotechnology, bio-inorganics **Reference books:**	45 h

11.	**GTT 2007 – Nanotechnology in Green Chemistry** *Theory of Nanoparticle Catalysis And Electrocatalysis:* Theory and modelling of catalytic and electrocatalytic reactions - some selected examples, Simulations of the reaction kinetics on nm supported catalyst particles, Electronic structure and chemisorption properties of supported metal clusters – model calculations *Model Systems - From Single Crystals To Nanoparticles:* State-of-the-art characterization of single crystal surfaces; Single crystal surfaces as model platinum-based fuell cell electrocatalysts, Electrochemical nanostructuring of surfaces, Adsorption and reaction at supported model catalysts, Size-dependent electronic, structural, and catalytic properties of metal clusters supported on ultra-thin oxide films, Physical and electrochemical characterization of bimetallic nanoparticle electrodes. *Synthetic Approaches In Nanoparticle Catalysis And Electrocatalysis:* Nanomaterials as precursors for electrocatalysts; preparation, characterization, and properties of bimetallic nanoparticles, Physicochemical aspects of preparation of carbon supported Nobel metal catalysis. *Particle Size, Support, And Promotional Effects*: Electrochemical and chemical promotion on metal films and nanoparticles Metal-supported interaction in low temperature fuel cell electrocatalysis Effects of nanoparticle size, structure, and metal-support interactions; promotion, electrochemical promotion and metal-support interactions, Support effects on catalytic performance of nanoparticles; abnormal infrared effects of nanometer scale thins film material of platinum group metals and alloys at electrode/electrolyte interfaces, Design of electrocatalysts for fuel cells; effect of particle size and support on some catalytic properties of metallic and bimetallic catalysts. *Advanced Electrocatalytic Materials:* Catalyst nanoparticles on synthetic diamond surfaces, Electrocatalysis with electron conduction polymers modified by platinum metal nanoparticles, Novel nanostructured material based on transition metal compounds for electrocatalysis. *Bulk Metal and Ceramics Nanocomposites*: Ceramic/Metal Nanocomposites, Metal Matrix Nanocomposites Bulk Ceramic Nanocomposites for Desired Mechanical Properties, Thin-Film Nanocomposites: Multilayer and Granular Films, Nanocomposites for Hard Coatings, Carbon Nanotube-Based Nanocomposites, Functional Low-Dimensional Nanocomposites, Inorganic Nanocomposites for Optical Applications, Inorganic Nanocomposites for Electrical Applications, Nanoporous Structures and Membranes: Other Nanocomposites, Nanocomposites for Magnetic Applications Magnetic Multilayer Nanocomposites, Nanocomposite Structures having Miscellaneous Properties, Concluding Remarks on Metal/Ceramic Nanocomposites *Polymer-based and Polymer-filled Nanocomposites:* Nanoscale Fillers, Nanofiber or Nanotube Fillers, Carbon Nanotubes, Nanotube Processing, Other Nanotubes, Plate-like Nanofillers Inorganic FillerPolymer Interfaces Processing of Polymer Nanocomposites, Nanoparticle/Polymer Composite Processing, Direct Mixing, Modification of Interfaces, Modification of Nanotubes, Properties of Composites, *Natural Nanobiocomposites, Biomimetic Nanocomposites, and Biologically Inspired Nanocomposites:* Natural Nanocomposite , Materials, Biologically Synthesized Nanoparticles, Biologically Synthesized Nanostructures, Biologically Derived Synthetic Nanocomposites, Protein-Based Nanostructure Formation, DNA-Templated Nanostructure Formation, Protein Assembly, Biologically Inspired Nanocomposites, Lyotropic Liquid-Crystal Templating, Liquid-Crystal Templating of Thin Films, Block-Copolymer Templating Colloidal Templating, *Modeling of Nanocomposites***:** Introduction The Need For Modeling Current Conceptual Frameworks, Multiscale Modeling, Multiphysics Aspects. **Reference books:**	45 h
12.	**Elective-III (from the list appended)** • Candidate will have to choose one of the elective subjects offered for that semester from the elective subjects. A consolidated list of all the elective subjects is given at the end.	45 h
13.	**Elective-IV (from the list appended)** • Candidate will have to choose one of the elective subjects offered for that semester from the elective subjects. A consolidated list of all the elective subjects is given at the end.	45 h
14.	**GTP 2003 – Project III** This would be concerned with a detailed and critical review of the area of the proposed research project to be undertaken in the second year and will be under the guidance of the research supervisor. **1.** The Seminar work is concerned with a detailed and critical review of an area of interest to Chemical Engineering. Typically, the report should contain and will be evaluated based on the following points: **(a)** Introduction: 2 pages maximum,	

(d) Exhaustive review of literature (including figures): 10 – 12 pages: 50% Weightage

(e) Critical analysis of the literature and comments on the analysis Critical analysis should also contain quantitative comparison of observations, results, and conclusion amongst the various papers.

2. Two typed copies of the report on thesis size bond paper (297 mm x 210 mm) are to be submitted to Coordinator on **time to be decided by the coordinator.** The detailed timetable for the presentation would be communicated.

3. The report should be prepared using the Times Roman font (size 12) using 1 1/2 spacing leaving 1-inch margin on all sides producing approximately 29 lines per page. The report should be typed on one side of the paper and need not be bound in a hard cover binding. Figures and tables should be shown as a part of the running text. Each figure should be drawn inside a rectangular box of 12 cm width and 10 cm height. The figures must be sufficiently clear and hand drawn figures will be acceptable. Particular care must be taken if a figure is photocopied from source. Each figure must have a sequence number and caption below. Each table must have a sequence number and title at the top.

4. Name of the student, title of the problem and year of examination must be indicated on the top cover. THE NAME OF THE SUPERVISOR (ONLY INITIALS) MUST APPEAR ON THE BOTTOM RIGHT CORNER OF THE TOP COVER.

5. The report must be precise. All important aspects of the topic should be considered and reported. **The total number of pages, including tables, figures, and references should not exceed 30.** Chapters or subsections need not be started on new pages, while getting the report typed.

6. Typographical errors in the report must be corrected by the student. The student will be discredited for any omission in the report. All the symbols used in the text should be arranged in an alphabetical order and given separately after conclusions.

7. The list of references should be arranged in alphabetical order of the names of authors. In the text, the reference should be cited with author's name and year. (author - date style) For example:

(i) The flow pattern in gas-liquid-solid fluidized bed has been reported in the published literature (Murooka et.al., 1982).

OR

(ii) Murooka et al. (1982) have measured flow patterns in gas-liquid-solid fluidized beds. The title of the article should also be included. The references must be given in the following standard format.

(a) Format for listing references of articles from periodicals: Murooka S., Uchida K. and Kato Y., Recirculation Turbulent Flow of Liquid in Gas- Liquid-Solid Fluidised Bed", J. Chem. Engg. Japan, 15, 29-34 (1982).

(b) Format for listing references of Books:
Constant R.F.,"Crystallization, Academic Press, New York, pp. 89-90, 1968.

(c) Format for listing Thesis:
Niranjan K., "Hydrodynamic and Mass Transfer Characteristics of Packed Columns", Ph.D. (Tech.) Thesis, University of Mumbai, 1983.

(d) Format for listing references of Patents in Chemical Abstracts:
Cananaush R.M., U.S.Patent 2,647,141, Cf. C.A. 48, 82636 (1954).

(e) Format for listing Handbooks, Tables, Symposia etc.:
Kumar R and Kuloor N.R., "Formation of Drops and Bubbles", in Advances in Chemical Engineering, Vol.8, T.B. Drew et.al. (Eds.) New York, Academic Press, pp.256-364 (1970).

(f) Format for listing Private Communications and other categories:
Sharma, M.M., Private Communication (1984).

(8) Consistency of units should be maintained in the written report. SI systems should be used. [For SI system - Ref: Ind. Chem. Engr., 24, 32, 3 (1983)]. Units used in the literature (if not SI) should be correctly converted.

(9) The time allotted for the oral presentation of seminar is 20 minutes: additional 10 minutes are provided for questions and answers.

(10) INCOMPLETE AND CARELESSLY WRITTEN REPORT IS LIABLE TO BE REJECTED.

(11) The last date for submission will NOT be extended on any grounds whatsoever.

(12) There must not be any acknowledgment about the guidance by the faculty in the Seminar.

(13) The Seminar will be evaluated on the basis of (i) rational approach to the problem, ii) correctness and completeness of the written text and iii) performance in the oral presentation.

	(14) Word-to-word copying from the published article is not permitted. Flowery language is not to be used.	

The following subjects can be offered as ELECTIVES

1.	**GTT 2101 Analysis and Development of Green Industrial Processes** Pollution statistics from various industries, Important example. Refinery industry -FCC, reforming, platforming, hydroforming, polymerisation, alkylation, isomerisation; hydrodesulfurisation, hydronitrogenation, Pharmaceutical and fine chemical industry, Dyestuff and intermediate industries, Perfume and flavour industry, Polymer industry, Textile industry, Paint industry, Edible oil industry, Food industry, Waste water treatment, Catalysis for auto-exhaust pollution abatement, DeNox, DeSOx technologies	
2.	**GTT 2102 Industrial Catalysts** Catalyst design, preparation and activation, Clay and modified clays, Ion exchange resins, Zeolites and zeotypes , Heteropoly acids, Inorganic-organic catalysts, Immobilised enzymes, zeozymes, complexes, Electrochemical catalysis, Photocatalysis, Microwave catalysis, Ultrasound catalysis, Synergistic catalysis. Bio-catalysis : Microbes and enzymes, Phase transfer catalysis, Micellar catalysis, Microemulsion catalysis, Electron transfer catalysis, Homogeneous polymer catalysis, Heterogenisation of homogeneous catalysts, Catalysis by microwaves and ultrasound, Catalyst recovery and reuse.	
3.	**GTT 2103 Green Product Design** Green product design definition, Product strategy, Life cycle of product, ISO 14000, Environmental load of product, Material selection, resource use, production requirements and planning for the final disposition (recycling, reuse, or disposal) of a product. Integration with existing product design approaches such as quality, producibility, and functionality. Upgradability, Disassebly, "Greening" Supplier Inputs, Improving Whole Systems, International laws on take-back laws, extended responsibility, Eco-labeling, Examples from Pharmaceuticals, Foods, Cosmetics, Packaging, Computers, Polymers, Automobiles, Electronics Industry.	
4	**GTT 2104 Environmental Engineering and Pollution Prevention** Air pollution: Definition of pollutants. Standards and limits of pollutants. Sources and sinks of pollutants. Meteorology. Problems associated with dispersion. Sampling techniques. Control techniques for removal of particulate and gaseous pollutants. Water pollution: Characterization of industrial wastewaters. Standards and limits of pollutants. Preliminary primary, secondary and tertiary treatment methods. Separation technique for removal and recovery of pollutants. Solid waste treatment. Socio-economic aspects recovery waste as abatement. End of pipe solutions, Life cycle analysis of plastics, papers, tins; Identification of wastestreams from processes, Waste minimization strategies, Prioritizing pollution prevention options, Selecting environmentally compatible materials, Design of unit operations for pollution prevention, Economics of pollution prevention, Process flow-sheeting for pollution prevention.	
5.	**GTT 2105 Industrial Safety and Hazard Analysis** Introduction ISO standards with reference to chemical industry, Safety aspects pertaining to the design of chemical plants. Industrial hygiene and safety aspects related to toxicity, noise, pressure, temperature, vibrations, radiations, etc. Explosions including dust, vapour cloud and mist explosions. Hazard identification, assessment and safety audit, HAZOP, HAZAN and consequence analysis. Safety aspects related to (i) transport handling and storage of flammable liquids and gases and toxic materials (ii) Process equipment including piping (fire, static electricity, pressure, temperature, etc.) Safety aspects at process development and design stage. Reliability engineering. Hazard mitigation systems Emergency planning. Case studies. Life cycle analysis of chemicals.	
6.	**GTT 2106 Chiral Engineering** Chirality and green chemistry, Preparation and Importance of Chiral Molecules, chirality in pharmaceuticals, agrochemicals and specilities, Wehland - Meischer Dione, Chiral Synthesis, , Crown Ether Technology, Nazarov's Reagent Production, Michael Addition, Chiral Analysis, Engineering of the ee, Computer Modeling.	
7.	**GTT 2107 Advances in Green Chemistry for Sustainable Development** This subject will be based on the lectures and seminars of visiting scientists, distinguished Chairs and persons from industry. A total of 15 such lectures will be organized during the semester. The idea behind such an elective is to expose the students to a variety of new topics on cutting edge. This also conforms to the 'open boundary' syllabus.	