B.Tech. Semester III

Subject Name: Green Engineering and Sustainable Development **Subject Code:** BTCH14301

Type of course: Professional Elective Course

Prerequisite: Basic knowledge of Environmental Science and Chemistry.

Rationale: To create better and safe chemicals while choosing the safest and the most efficient ways to synthesize them and to bring in the importance and the underlying principles of green and sustainable technology.

Teaching and Examination Scheme:

TEACHING SCHEME				Theory Marks			Practical Marks		Total
L	T	P	C	TEE	CA1	CA2	TEP	CA3	100
3	0	0	3	60	25	15	00	00	

CA1: Continuous Assessment (assignments/projects/open book tests/closed book tests **CA2:** Sincerity in attending classes/class tests/ timely submissions of assignments/self-learning attitude/solving advanced problems **TEE:** Term End Examination **TEP:** Term End Practical Exam (Performance and viva on practical skills learned in course) **CA3:** Regular submission of Lab work/Quality of work submitted/Active participation in lab sessions/viva on practical skills learned in course

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage (%)
1.	**Principles of Green Chemistry and Green Engineering:** Concepts of green chemistry and process intensification, principles of green chemistry, to learn to modify the processes and products to make them green safe and economically acceptable to the society	4	12
2.	**Green chemistry metrics:** atom economy, E factor, reaction mass efficiency and other green chemistry metrics, application of green metrics analysis to synthetic plans	5	10
3.	**Green Synthesis and Catalysis:** Green synthesis, Designing green processes- safe design, Green oxidation and photochemical reactions, Microwave and Ultrasound assisted reactions, Synthesis of Green Reagents, Green solvents, Ionic liquids and Green nanotechnology.	9	20
4.	**Green Industrial Processes:** Pollution statistics from various industries like polymer, textile, pharmaceutical, dyes,pesticides and wastewater treatment. A greener approach towards all these industries and case studies.	9	20
5.	**Meaning of Sustainable Development:** Understand the Sustainable Development, three principal	5	13

	dimensions: the ecological, theeconomic and the social dimension, including intergenerational, Goals of sustainable development, challenges to meet sustainability requirements.		
6.	**Concepts of Cleaner Technologies**:Cleaner Production (CP), Definition, methodology, Role of CP in Achieving Sustainability,Benefits, Role of Industry, Government and Institutions, Environmental ManagementHierarchy, Relation of CP and EMS, CP case studies.	8	**15**
7.	**Challenges and Practical Implementation:**Responsibilities and potentials of companies for action. Green Productivity and emergingtechnologies. Implementation of the practical applications of Green emerging technologies, Green laws compliance.	5	**10**

Suggested Specification table with Marks (Theory/Practical):

% Distribution of Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
25	30	30	15	-	-

Legends: R: Remembrance, **U:** Understanding; **A:** Application, **N:** Analyze, **E:** Evaluate **C:** Create and above Levels **(Revised Bloom's Taxonomy)**

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Text Books:

Sr. No.	Title of book /article	Author(s)	Publisher and details like ISBN	Year of publication	Publication Edition
1	Green Chemistry An introductory text	M. Lancaster	RSC, Print ISBN 978-1-78262-294-9	2016	3rd
2	Green Chemistry Metrics: Measuring and Monitoring Sustainable Processes	Alexi Lapkin and david Constable	Wiley publicationsISBN: 978-1-405-15968-5	2008	1st
3	Introduction to Green Chemistry	Matlack A.S.	CRC Press ISBN 9781498770507	April 9, 2010	2nd
4	Green Chemistry: Theory and Practice	Anastas P.T. and Warner J.C.	Oxford University Press ISBN-10: 9780198506980	7 March 2005	Reprint

5.	Handbook of Green Chemistry and Technology	Clark J.H. and Macquarrie D.J.	WileyBlackwell Publishers ISBN: 978-0-632-05715-3	2002	1st
6.	Environmental chemistry	Stanley E Manahan	CRC PressISBN-10 : 1420059203	December 2009	9th

Course Outcome:

Sr. No.	CO Statement After learning this subject, students will be able to	Marks % weightage
CO-1	Understand the principles of green chemistry and engineering	15
CO-2	Design processes that are benign and environmentally viable	15
CO-3	Design processes and products that are safe and hazard free	35
CO-4	Learn to modify processes and products to make them green safe and economically acceptable.	35

Mapping with POs:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO-1	3	3	2	1	1	3	3	3	2	2	2	3	2	2	2
CO-2	3	3	2	1	1	3	3	3	2	2	2	3	2	2	1
CO-3	3	3	2	1	1	3	3	3	2	2	2	3	1	1	1
CO-4	3	3	2	1	1	3	3	3	2	2	2	2	2	2	3
Rationale*	12	12	8	4	4	12	12	12	8	8	8	11	7	7	7

Rationale*: Explaining why it is matching this particular program outcome

List of Open Source/learning website:http://www.gcpcenvis.nic.in/Default.aspx