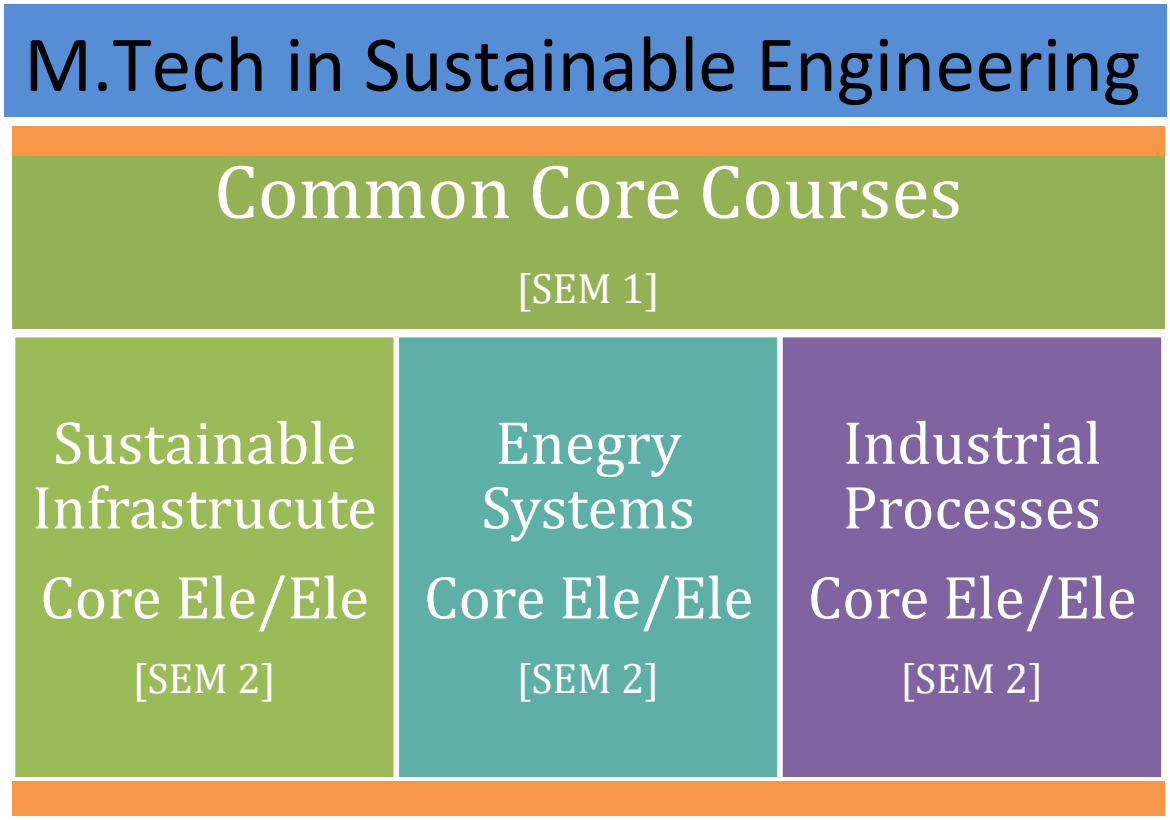
Curriculum For M.Tech. In Sustainable Engineering

Preamble

The M.Tech program offers three different specializations under the Sustainability Theme, Viz. ***Sustainable Infrastructure, Energy Systems, and Industrial Processes***. These specializations will be offered from the second semester. In the first semester, students will take all common core courses. From the second semester, students will opt for one of the specializations and choose courses from the basket of courses from each specialization. The program template is shown below.



Semester	Course Type	Credits
Semester 1	Core	14
Semester 2	Core Ele/ Ele	11 or 12
Semester 3	Thesis	12
Semester 4	Thesis	12
Total		**49-50**

SEMESTER I (Common to all specializations)

	Course	Course Codes	Credits	Type
	Concepts in Sustainable Engineering	SE50723	3	Core
	Sustainable Energy Technology	ME50480	3	Core
	Analysis and Methods for Sustainable Engineering	SE50713	2	Core
	Green Chemistry and Industrial Processes	SE50500	2	Core
	Sustainable Building Materials	SE50100	3	Core
	English Communication	LAxxxx	1	Core
	Total		14	

SEMESTER II Courses

One specialization basket is to be chosen.
Choose a minimum of 9 elective credits of course from the chosen basket.

- Industry Lecture 1 unit
- Research Writing 1 unit as compulsory.

S. No	Courses	Credits	Type	Course Code
1	**Sustainable Infrastructure**			
	Sustainable Highway Infrastructure Design and Retrofitting	3	Elective	SE50110
	Energy-efficient buildings	2	Elective	SE50120
	Sustainable Waste Management	2	Elective	SE50130
	Structural resilience strategies	3	Elective	SE50150
	Strategies for Sustainable Design	2	Elective	SE50160
	Sustainable Mobility	3	Elective	SE50170
2	**Energy Systems**			

	Photovoltaic Technologies and Solar Economy	3	Elective	SE50310
	Hydrogen Economy	2	Elective	ET5024
	Bioenergy	2	Elective	ET5060
	Wind Energy Technology	3	Elective	SE50350
	Chemistry for Sustainable Energy	2	Elective	SE50360
	Sustainable Mobility	3	Elective	SE50170
3	**Industrial Processes**			
	Net Zero Processes	3	Elective	SE50510
	Optimization Techniques	2	Elective	CH5190
	Swot Analysis and Risk Management	2	Elective	EW50120
	Carbon Capture Utilization and Storage	3	Elective	SE50520
	Supply Chain Management and Circular Economy	1	Elective	EW50090
	Machine Learning for Process Systems Engineering	1	Elective	CH6870
	Decision Modelling	1	Elective	EM50050
	Sustainable Waste Management	2	Elective	SE50130
	Technologies for Sustainable Manufacturing	1	Elective	SE50540
	Parallel & Concurrent Programming	3	Elective	CS5300
	Distributed Computing	3	Elective	CS5320

	M Tech Thesis Stage 1	12	Core	SE 60015
	M Tech Thesis Stage 2	12	Core	SE 60025

Course Descriptions

SEMESTER 1

1. SE 50723 Concepts in Sustainable Engineering

Proposed New Course Template		
Fields	Values	Remarks
Date	15.09.2023	Course proposed date
Old Course Code	CC50610	In case of interdisciplinary course, it should be IDxxxx'.
New Course Code	SE50723	In case of interdisciplinary course, it should be IDxxxx'.
Course Name	Concepts in Sustainable Engineering	
Credits	3 (2+1)	1, 2, 3, etc.
Pre-Requisites (if any)	None	Can be a Boolean Formula with ORs, ANDs and NOT (courses not to be taken along with this course)
Nature of Course	Combined theory and lab	Theory, Lab, Design, Combined theory and lab, combined design and tutorial/lab, project /thesis, seminar
Type of Course	Core	Core, Elective, interdisciplinary, etc.
Targeted Program and Year	B. Tech (IV) and M Tech	BTech (I, II, III or IV), B.Des, M.Sc, M.Tech, M.Des, MA, PhD, etc.

Contents	Sustainabilty - Definition; social, environmental, and economic components of Sustainabilty; Sustainability concepts using LCA, Resource allocation, materials cycle, energy balance, Impact and Risk analysis, environmental cost analysis; sustainable routes: waste management, pollution abatement, and treatment, resource recovery; United Nations Sustainable Development Goals (UNSDGs); Data interpretation and documentations. Laboratory sessions on software/packages related to LCA, resources flow (material and energy) and allocations, impact and risk analysis, and SDGs; Hands on experience on mass and energy balance, circular economy, and resources utilization. Practice sessions on data interpretation, sustainable solutions, and documentation.	
References	• Bradley A S, Adebayo A O, Maria P, Engineering Applications in Sustainable Design and Development, Cengage Learning 2016 • Jeffrey D S, The Age of Sustainable Development, Columbia University Press 2015 • Surjya Narayana Pati, Life Cycle Assessment Future Challenges, CRC Press 2022 • Guido Sonnemann Francesc Castells Marta Schuhmacher, Integrated Life-Cycle And Risk Assessment For Industrial Processes, CRC publications, 2004 • Fraser Smith, Environmental Sustainability Practical Global Applications 1997, 11th Edition 2020, CRC Press.	Minimum two references have to be provided along with the Year and Edition

Course Objective	The students will learn the connection between (i) resource allocation and environmental sustainability (ii) Pollution and life on the planet and (iii) Life cycle analysis and SDGs of these connections in detailed theoretical and practical aspects with hands on practice	List of items student should know on passing the course
Justification:	Basic overview of Sustainable Engineering concepts with detailed theoretical classes and laboratory sessions	1) Philosophy of the course 2) If the course matches in content with another course, please provide a comparison. Any two courses should not match largely

2. SE 50713 Analysis and Methods for Sustainable Engineering

Proposed New Course Template		
Fields	**Values**	**Remarks**
Date	Jun 2023	Course proposed date
Course Code	SE50713	In case of interdisciplinary course, it should be IDxxxx'.
Course Name	Analysis and Methods for Sustainable Engineering	
Credits	2	1, 2, 3, etc.
Pre-Requisites (if any)	None	Can be a Boolean Formula with ORs, ANDs and NOT (courses not to be taken along with this course)
Nature of Course	Theory + Lab	Theory, Lab, Design, Combined theory and lab, combined design and tutorial/lab, project /thesis, seminar
Type of Course	Elective	Core, Elective, interdisciplinary, etc.
Targeted Program and Year	M.Tech, PhD, etc.	BTech (I, II, III or IV), B.Des, M.Sc, M.Tech, M.Des, MA, PhD, etc.
Contents	This course provides students an opportunity to learn and use analytical tools and methods to solve problems related to sustainable engineering.	

	Contents: Introduction, Linear Regression, Nonlinear regression, Optimization, Linear Programming and Integer Programming for resources allocation, Landscape conservation, Stochastic Optimization, and Markov Process, Introduction for Big Data and Geospatial Analysis	
References	• Systems Analysis for Sustainable Engineering Theory and Applications, Mc Graw Hill Publications. 2016 • Sustainable Engineering: Drivers, Metrics, Tools, and Applications • Krishna R. Reddy, Claudio Cameselle, Jeffrey A. Adams, Wiley 2019	Minimum two references have to be provided along with the Year and Edition
Course Objective	The objective of this course is to introduce the principles of systems analysis for sustainable engineering theory and application. And to train the students in mathematical theories for systems analysis and their application to natural resources management, and industrial ecology and sustainable design.	List of items student should know on passing the course
Justification:	It is a new course and it is important topic under sustainability engineering.	1) Philosophy of the course 2) If the course matches in content with another course, please provide comparison. Any two courses should not match largely

3. SE50500 Green Chemistry and Industrial Processes

Proposed New Course Template		
Fields	Values	Remarks
Date	Apr 2024	Course proposed date
Course Code	SE50500	In case of interdisciplinary course, it should be IDxxxx'.
Course Name	Green Chemistry and Industrial Processes	
Credits	2	1, 2, 3, etc.
Pre-Requisites (if any)	N/A	Can be a Boolean Formula with ORs, ANDs and NOT (courses not to be taken along with this course)
Nature of Course	Theory	Theory, Lab, Design, Combined theory and lab, combined design and tutorial/lab, project /thesis, seminar
Type of Course	Core	Core, Elective, interdisciplinary, etc.
Targeted Program and Year	M.Tech	BTech (I, II, III or IV), B.Des, M.Sc, M.Tech, M.Des, MA, PhD, etc.

Contents	The twelve Principles of Green Chemistry and green engineering with examples Waste Minimisation/Prevention. Establishing a full mass balance. Waste treatment/recycle Green chemistry metrics- atom economy, E factor, reaction mass efficiency, and other green chemistry metrics, application of green metrics analysis to synthetic plans Synthesis Plans Analysis: Synthesis Tree Algorithms for Linear and Convergent Plans Raw Material Cost Estimate Material Resource Efficiency & Synthetic Elegance Less Hazardous Materials in Synthesis Safer Solvents and Auxiliaries. Energy Efficiency. Quantifying and minimizing the use of utilities and, other inputs. Photochemistry, Microwave chemistry, Sonochemistry, Electrosynthesis, Energy Sources Green Chemistry and Catalysis, Homogeneous and Heterogeneous Catalysis in Environmentally Benign reactions and Solvents Renewable Feedstocks, Sustainability measures. Biomass vs Fossils CO_2 and Global Warming and CO_2 Utilization Biopolymers/Sustainable polymers (Waste recycling: paper, plastics, moving to a circular economy) Hazard Minimisation. Process safety and thermal hazards. Appreciation of chemical engineering concepts. Process intensification Industrial applications of green chemistry Green Chemistry for Bio-pesticides and the Pharmaceutical Industry Chlorine-Free Synthesis vs Polycarbonates/Polyurethanes	

References	• Anastas, P.T. & Warner, J.K.: Green Chemistry - Theory and Practical, Oxford University Press (1998). • Matlack, A.S. Introduction to Green Chemistry, Marcel Dekker (2001). • Cann, M.C. & Connely, M.E. Real-World cases in Green Chemistry, American Chemical Society, Washington (2000). • Ryan, M.A. & Tinnes and, M. Introduction to Green Chemistry, American Chemical Society, Washington (2002). • Lancaster, M. Green Chemistry: An Introductory Text RSC Publishing, 2nd Edition, 2010.	Minimum two references have to be provided along with the Year and Edition
Course Objective	Green chemistry and industrial process is the utilization of principles that reduce or eliminate the use or generation of hazardous substances in the design, manufacture, and application of chemical products, including fuels, plastics, polymers, pharmaceuticals, fragrances, and agriculture-based products. During the course, we will discuss the basic design rules for Green Chemistry and see some of the synthesis strategies, solvents, and catalysts that we have available to apply. Since chemical processes are often linked together into a network, we will also zoom out and analyze how the biggest industrial processes are connected. This will allow us to evaluate where some of the "big issues" in our chemical industry come from, and to pinpoint where in the network of reactions Green Chemistry can make the most effective contribution.	List of items student should know on passing the course

Justification:	No other similar courses in IITH.	1) Philosophy of the course 2) If the course matches in content with another course, please provide comparison. Any two courses should not match largely

4. SE 50100 Sustainable Building Materials

Proposed New Course Template		
Fields	Values	Remarks
Date	15.09.2023	Course proposed date
Old Course Code	--	In case of interdisciplinary course, it should be IDxxxx'.
New Course Code	SE50100	In case of interdisciplinary course, it should be IDxxxx'.
Course Name	Sustainable Building Materials	
Credits	3	1, 2, 3, etc.
Pre-Requisites (if any)	None	Can be a Boolean Formula with ORs, ANDs and NOT (courses not to be taken along with this course)
Nature of Course	Theory	Theory, Lab, Design, Combined theory and lab, combined design and tutorial/lab, project /thesis, seminar
Type of Course	Core	Core, Elective, interdisciplinary, etc.
Targeted Program and Year	M.Tech, Ph.D.	BTech (I, II, III or IV), B.Des, M.Sc, M.Tech, M.Des, MA, PhD, etc.

Contents	This course aims to expose the students to the concepts of sustainability in the context of building and conventional engineered construction materials, such as concrete, bricks, and steel. Sustainability of construction material from production, lifetime use and recycling are developed. The concepts of embodied, operational, and life cycle energy are introduced. Net-zero and life cycle analysis concepts are presented for managing carbon footprint. Strategies for achieving low carbon and energy targets are reviewed, including Low carbon cements and recycled aggregate, minimizing consumption of natural resources, including water. Evaluations by agencies like ECBC, LEED, and GRIHA will be described. Module 1: Embodied energy, Operational energy in Building, and Life cycle energy. Ecological footprint, Bio-capacity, and calculation of planet equivalent. (1 week) Module 2: Role of Material: Carbon from Cement, Basics of Cement production and Chemistry (1 week) Module 3: Alternative cements and Cementitious materials. Strategies for reducing the carbon footprint of cement. Alternative fuel for cement for the reduction in carbon emission. High-volume fly ash concrete, geo-polymer concrete etc., concrete with alternative material for sustainability. (3 weeks) Module 4: Materials in concrete and material demand. Aggregate, Sustainability issues for concrete (1 week) Module 5: Durability issues in concrete, life cycle analysis (2 weeks) Module 6: Role of quality, minimization of natural resource utilization, lean construction (1	

	week) Module 7 : Reduction in water consumption in concrete, Recycled aggregate, Energy for grinding, crushing of cement aggregate etc., and reduction. (1 week) Module 8 : Operational energy in building role of materials and thermal conductivity (1 week) Week 8 : Operational energy reduction and net zero building, Optimization for the design of the building for energy efficiency (1 week) Module 9: Green Performance rating, requirements of LEED, GRIHA etc. (1 week).	

References	• Materials for Sustainable Sites: A Complete Guide to the Evaluation, Selection, and Use of Sustainable Construction Materials. 2008 Meg Calkins ISBN: 978-0-470-13455-9 Wiley Publishers • Practical handbook on Energy conservation in buildings. Indian Building congress. 2008. ISBN-10 : 8172746377 Nabhi publishers. • Green building, an engineering approach. 2024. Christian Carrico ISBN: 9780128243657. Elsevier • Sustainable Construction and building materials. 2019. Select Proceedings of ICSCMB 2018. ISBN: 978-981-13-3316-3. Springer. • ISO15686-5, 2017. Buildings and Constructed Assets Service Life Planning Part 5: Life-Cycle Costing. International Standard copyright office Ch. de Blandonnet 8, CP 401 CH-1214 Vernier, Geneva, Switzerland. • ISO14040, 2022. ISO 14040: environmental management - life cycle assessment- Principles and framework. Int. Organ. Stand. 3. • ISO14044, 2006. ISO 14044: environmental management - life cycle assessment - requirements and guidelines. Int. Organ. Stand.	Minimum two references have to be provided along with the Year and Edition

Course Objective	This course aims to expose the students to the concepts of sustainability in the context of building and conventional engineered construction materials, such as concrete, bricks, and steel. Sustainability of construction material from production, lifetime use and recycling are developed. The concepts of embodied, operational, and life cycle energy are introduced. Net-zero and life cycle analysis concepts are presented for managing carbon footprint. Strategies for achieving low carbon and energy targets are reviewed, including Low carbon cements and recycled aggregate, minimizing consumption of natural resources, including water. Evaluations by agencies like ECBC, LEED, and GRIHA will be described.	List of items student should know on passing the course
Justification:	The concepts of sustainable building materials is a core course for the specialization in Sustainable Infrastructure program. The concepts are crucial in selecting sustainable building materials for infrastructure development.	1) Philosophy of the course 2) If the course matches in content with another course, please provide comparison. Any two courses should not match largely

SEMESTER 2

SUSTAINABLE INFRASTRUCTURE

5. SE 50110 Sustainable Highway Infrastructure Design and Retrofitting

Proposed New Course Template		
Fields	Values	Remarks
Date	Apr 2024	Course proposed date
Course Code	SE50110	In case of interdisciplinary course, it should be IDxxxx'.
Course Name	Sustainable Highway Infrastructure Design and Retrofitting	
Credits	3	1, 2, 3, etc.
Pre-Requisites (if any)	None	Can be a Boolean Formula with ORs, ANDs and NOT (courses not to be taken along with this course)
Nature of Course	Theory	Theory, Lab, Design, Combined theory and lab, combined design and tutorial/lab, project /thesis, seminar
Type of Course	Core	Core, Elective, interdisciplinary, etc.
Targeted Program and Year	M Tech	BTech (I, II, III or IV), B.Des, M.Sc, M.Tech, M.Des, MA, PhD, etc.

Contents	The course equips participants with the knowledge of sustainable highway construction materials, including alternate/marginal aggregates, stabilized base, and subbase materials, geosynthetic reinforcement, etc. The course will be conducted as per the modules below: 1. Introduction to highway construction materials 2. Engineering behavior of marginal aggregates and recycled materials 3. Methods of improving the engineering behavior of alternate materials. 4. Geosynthetics 5. Design aspects of highways with conventional and alternate materials, including geopolymer stabilized bases, geosynthetic-reinforced bases, and subbases. 6. Pavement evaluation and rehabilitation	
References	• Sustainable Highways, Pavements and Materials, by Kasthurirangan Gopalakrishnan, First Edition 2011, ISBN-13 978-1530366033 • Sustainable Infrastructure: Principles into practice, Second edition, Richard Fenner, Judith Sykes and Charles Ainger, Emerald Publishing, 2022.	Minimum two references have to be provided along with the Year and Edition
Course Objective	The students will learn the design of highway infrastructure using alternate materials, geosynthetics, field performance, and retrofitting.	List of items student should know on passing the course

Justification:	Highway infrastructure development is a key component of sustainable socio-economic development. It is a new course and doesn't match with any existing course.	1) Philosophy of the course 2) If the course matches in content with another course, please provide comparison. Any two courses should not match largely

6. SE 50120 Energy-efficient Buildings

Proposed New Course Template		
Fields	Values	Remarks
Date	15.09.2023	Course proposed date
Old Course Code	--	In case of interdisciplinary course, it should be IDxxxx'.
New Course Code	SE50120	In case of interdisciplinary course, it should be IDxxxx'.
Course Name	Energy-efficient buildings	
Credits	2	1, 2, 3, etc.
Pre-Requisites (if any)	None	Can be a Boolean Formula with ORs, ANDs and NOT (courses not to be taken along with this course)
Nature of Course	Theory	Theory, Lab, Design, Combined theory and lab, combined design and tutorial/lab, project /thesis, seminar
Type of Course	Core	Core, Elective, interdisciplinary, etc.
Targeted Program and Year	B. Tech (III, IV) and M Tech (Sustainable Engg. and Climate Change)	BTech (I, II, III or IV), B.Des, M.Sc, M.Tech, M.Des, MA, PhD, etc.
Contents	The course equips participants with the latest knowledge on how to improve the energy efficiency of a building, reduce expenditure & lessen CO2 emissions. The course enables participants to work successfully in the renewables and energy efficiency industry.	

References	• "Energy-Efficient Building Systems: Green Strategies for Operation and Maintenance" by Lal Jayamaha and Asif Syed • "Sustainable Construction: Green Building Design and Delivery" by Charles J. Kibert • "Passive House Design: Planning and Design of Energy-Efficient Buildings" by Jan Cremers and Rainer Vallentin • "Building Science for Architects" by Lisa Heschong	
Course Objective	The course equips students with the latest concepts on how to improve the energy efficiency of a building, reduce expenditure & lessen CO2 emissions.	List of items student should know on passing the course
Justification:	Basic overview of energy-efficient buildings with theoretical and detailed laboratory sessions. This is a new course.	1) Philosophy of the course 2) If the course matches in content with another course, please provide comparison. Any two courses should not match largely

7. SE 50130 Sustainable Waste Management

Proposed New Course Template		
Fields	Values	Remarks
Date	Apr 2024	Course proposed date
Course Code	SE50130	In case of interdisciplinary course, it should be IDxxxx'.
Course Name	Sustainable Waste Management	
Credits	2	1, 2, 3, etc.
Pre-Requisites (if any)	Students who have taken Solid Waste Management as a course or as a part of the Environmental Engineering course at the bachelor level	Can be a Boolean Formula with ORs, ANDs and NOT (courses not to be taken along with this course)
Nature of Course	Theory	Theory, Lab, Design, Combined theory and lab, combined design and tutorial/lab, project /thesis, seminar
Type of Course	Elective	Core, Elective, interdisciplinary, etc.
Targeted Program and Year	M. Tech.	BTech (I, II, III or IV), B.Des, M.Sc, M.Tech, M.Des, MA, PhD, etc.

Contents	Global change, sustainability, and adaptive management strategies for SWM - Functional elements - Waste minimization techniques and strategies - Systems engineering principles and tools - Industrial ecology and integrated SWM strategies - LCA in SWM - Carbon footprint-based SWM - Liquid waste management - circular economy	
References	• Tchobanoglous et al., Integrated Solid Waste Management: Engineering Principles and Management Issues, McGraw-Hill, 1993. • Chang & Pires, Sustainable Solid Waste Management: A Systems Engineering Approach, Wiley, 2015. • Sustainable Solid Waste Collection and Management" by Ana Pires, Graça Martinho, Susana Rodrigues, Maria Isabel Gomes - Published by Springer Nature • • "Concept of Zero Liquid Discharge: Innovations and Advances for Sustainable Wastewater Management" by Vidya Shetty Kodialbail, Chaudhery Mustansar Hussain - Published by Springer Singapore • • "Effective Waste Management and Circular Economy: Legislative Framework and Strategies (The Circular Economy in Sustainable Solid and Liquid Waste Management)"	Minimum two references have to be provided along with the Year and Edition

	by Carlos Roberto Vieira da Silva, Harish Hirani, Sadhan Kumar Ghosh, Sasmita Samanta - Published by Springer Nature Switzerland AG.	
Course Objective	The primary objective of this course is to equip students with the knowledge, skills, and practical approaches to manage solid waste in an environmentally sustainable, economically viable, and socially responsible manner. By achieving these objectives, the course should empower students with a comprehensive understanding of sustainable solid waste management principles, techniques, and practical applications, enabling them to contribute to the development of sustainable waste management solutions in various contexts.	List of items student should know on passing the course
Justification:	There are no other courses like this one in IITH. The Solid Waste Management course offered by the Civil Engineering Department focuses on the engineering principle and design aspects of developing solid waste management systems. However, this course offered by the Greenko School of Sustainability analyzes solid waste management from a systemic, sustainable, and circular economy perspective. These two courses complement each other.	1) Philosophy of the course 2) If the course matches in content with another course, please provide comparison. Any two courses should not match largely

8. SE 50160 Strategies for Sustainable Design

Proposed New Course Template		
Fields	Values	Remarks
Date	Apr 2024	Course proposed date
Course Code	SE50160	In case of interdisciplinary course, it should be IDxxxx'.
Course Name	Strategies for Sustainable Design	
Credits	2	1, 2, 3, etc.
Pre-Requisites (if any)		Can be a Boolean Formula with ORs, ANDs and NOT (courses not to be taken along with this course)
Nature of Course	Theory	Theory, Lab, Design, Combined theory and lab, combined design and tutorial/lab, project /thesis, seminar
Type of Course	Elective	Core, Elective, interdisciplinary, etc.
Targeted Program and Year	M. Tech.	BTech (I, II, III or IV), B.Des, M.Sc, M.Tech, M.Des, MA, PhD, etc.

Contents	The course introduces the principle of sustainability in design, the prevalent issues (world / India), approaches towards addressing sustainability, models, methods and tools to analyze and intervene. Course is developed to how ecological design and planning strategies can be developed in a responsive manner for human needs and biosphere. The course offers learning opportunities to enrich design process with ecological sensitivities, working along with nature, stimulate natural systems for design and development of resilient, responsive designs.	
References	• Rottle, Nancy., Yocom, Ken., Ecological Design, AVA Book, Switzerland. 2010 • Tukker, Arnold, Martin Charter, Carlo Vezzoli, Eivind Sto, and Maj Munch Andersen, eds. System Innovation for Sustainability: Volume 1:Perspectives on Radical Changes to Sustainable Consumption and Production.Greenleaf Publishing, 2007 • Tischner, Ursula, Eivind Sto, Unni Kjaernes, and Arnold Tukker, eds.System Innovation for Sustainability 3: Case Studies in Sustainable Consumption and Production - Food and Agriculture. Greenleaf Publishing,2009 • Benyus, Janine M. Biomimicry: Innovation Inspired by Nature. William Morrow Paperbacks,2002 • Harding, Dr Stephan, ed. Grow Small, Think Beautiful: Ideas for a Sustainable World from Schumacher College. Floris Books, 2011	Minimum two references have to be provided along with the Year and Edition

Course Objective	Dematerialization Thinking Alternatives Nature as Inspirations Emerging Practices Integrating Science and Design Design Process for Health of Ecosystem Case Studies	List of items student should know on passing the course
Justification:	No other similar courses in IITH.	1) Philosophy of the course 2) If the course matches in content with another course, please provide comparison. Any two courses should not match largely

9. SE 50170 Sustainable Mobility

Proposed New Course Template		
Fields	Values	Remarks
Date	Apr 2024	Course proposed date
Course Code	SE50170	In case of interdisciplinary course, it should be IDxxxx'.
Course Name	Sustainable Mobility	
Credits	3	1, 2, 3, etc.
Pre-Requisites (if any)		Can be a Boolean Formula with ORs, ANDs and NOT (courses not to be taken along with this course)
Nature of Course	Combined (2 Theory, 1 Lab)	Theory, Lab, Design, Combined theory and lab, combined design and tutorial/lab, project /thesis, seminar
Type of Course	Elective	Core, Elective, interdisciplinary, etc.
Targeted Program and Year	M. Tech.	BTech (I, II, III or IV), B.Des, M.Sc, M.Tech, M.Des, MA, PhD, etc.

Contents	Policies, Carbon Budget, Carbon Burden, Vehicular Carbon Emissions, Reductions of Carbon Emission. It will investigate three broad strategies for reducing greenhouse gas emissions: 1) reducing motorized travel, 2) shifting to less energy intensive modes, and 3) changing fuel and propulsion technologies. Hands on experience on collecting data related to transportation emissions	
References	• Driving Climate Change: Daniel Sperling and James Canon, Elsevier, 2007, ISBN: 978-0-12-369495-9 • Eco Cities and Green transport: Huapu Lu, Elsevier, 2020, ISBN: 978-0-12-821516-6 • Innovations in Fuel Economy: Woodhead Publishers, 2011, ISBN: 0857092138	Minimum two references have to be provided along with the Year and Edition
Course Objective	Evaluation of current practices and policies related to Sustainable Mobility	List of items student should know on passing the course
Justification:	The concept of sustainable mobility has had a relatively short life, first being used about 30 years ago. Transport is still not contributing enough to the internationally set reduction targets for carbon emissions. This course will provide students with the latest information regarding greenhouse emissions while presenting the most up-to-date techniques for reducing these emissions.	1) Philosophy of the course 2) If the course matches in content with another course, please provide comparison. Any two courses should not match largely

10. SE 50310 Photovoltaic technologies and solar economy

Proposed New Course Template		
Fields	Values	Remarks
Date	Apr 2024	Course proposed date
Course Code	SE50310	In case of interdisciplinary course, it should be IDxxxx'.
Course Name	Photovoltaic technologies and solar economy.	
Credits	2	1, 2, 3, etc.
Pre-Requisites (if any)	None	Can be a Boolean Formula with ORs, ANDs and NOT (courses not to be taken along with this course)
Nature of Course	Theory	Theory, Lab, Design, Combined theory and lab, combined design and tutorial/lab, project /thesis, seminar
Type of Course	Elective	Core, Elective, interdisciplinary, etc.
Targeted Program and Year	M. Tech.	BTech (I, II, III or IV), B.Des, M.Sc, M.Tech, M.Des, MA, PhD, etc.

Contents	Characteristics of the photovoltaic cell; Semiconductor Basics; Silicon solar cells; Thermodynamic limit to efficiency, Light management, electrical losses, thin-film silicon solar cells; Advanced strategies for high-efficiency solar cells; Chalcogenides & III-V Technologies; Organic Photovoltaics; Hybrid Technologies; PV modules. PV Plant components and architecture; sizing of PV systems based on load profile; PV system performance monitoring and analysis; economic analysis of PV systems; policy and regulatory framework for solar energy; solar energy markets and industry trends.	
References	• The Physics of Solar Cells by Jenny Nelson, Imperial College Press-2013. • Solar Photovoltaics: Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI Learning PVT Ltd. • Third Generation Photovoltaics: Advanced Solar Energy Conversion, by Martin Green, Springer	Minimum two references have to be provided along with the Year and Edition
Course Objective	The objective is to understand solar cell technology at the panel and plant levels.	List of items student should know on passing the course

Justification:	No other similar courses in IITH.	1) Philosophy of the course 2) If the course matches in content with another course, please provide comparison. Any two courses should not match largely

11. SE 50350 Wind Energy Technology

Proposed New Course Template		
Fields	Values	Remarks
Date	Apr 2024	Course proposed date
Course Code	SE50350	In case of interdisciplinary course, it should be IDxxxx'.
Course Name	Wind Energy Technology	
Credits	3	1, 2, 3, etc.
Pre-Requisites (if any)		Can be a Boolean Formula with ORs, ANDs and NOT (courses not to be taken along with this course)
Nature of Course	Theory	Theory, Lab, Design, Combined theory and lab, combined design and tutorial/lab, project /thesis, seminar
Type of Course	Elective	Core, Elective, interdisciplinary, etc.
Targeted Program and Year	M. Tech.	BTech (I, II, III or IV), B.Des, M.Sc, M.Tech, M.Des, MA, PhD, etc.

Contents	Wind power meteorology, turbine blade aerodynamics, tower structure strength, fatigue, farm aerodynamics and wake losses, electric generator and grid integration, resource assessment, life-cycle assessment	
References	• "Wind Energy Engineering" by P. Jain, 2nd edition, McGraw Hill Education, 2016. ISBN: 9780071843843 • "Wind Energy Engineering: A Handbook of Onshore and Offshore Wind Turbines", by T. Letcher, Elsevier Inc., 2017. ISBN: 9780128094518	Minimum two references have to be provided along with the Year and Edition
Course Objective	To provide an overview of engineering aspects related to harnessing energy from the wind.	List of items student should know on passing the course
Justification:	No other similar courses in IITH.	1) Philosophy of the course 2) If the course matches in content with another course, please provide comparison. Any two courses should not match largely

12. SE 50360 Chemistry For Sustainable Energy

Proposed New Course Template		
Fields	Values	Remarks
Date	Apr 2024	Course proposed date
Course Code	SE50360	In case of interdisciplinary course, it should be IDxxxx'.
Course Name	Chemistry for Sustainable Energy	
Credits	2	1, 2, 3, etc.
Pre-Requisites (if any)		Can be a Boolean Formula with ORs, ANDs and NOT (courses not to be taken along with this course)
Nature of Course	Theory	Theory, Lab, Design, Combined theory and lab, combined design and tutorial/lab, project /thesis, seminar
Type of Course	Elective	Core, Elective, interdisciplinary, etc.
Targeted Program and Year	MSc, MTech, PhD, BTech (III, IV)	BTech (I, II, III or IV), B.Des, M.Sc, M.Tech, M.Des, MA, PhD, etc.

Contents	Chemistry for Renewable Energy provides cutting-edge expertise through thorough research in this field. Research includes physical and chemical fundamentals that can participate in the development of new solutions for the sustainable production of electricity and fuels, and energy storage. Understanding the chemistry behind sustainable energy is critical in creating solutions to meet the world's future energy needs. Understanding the chemistry of the energy sector and having the skills and knowledge to change and develop systems from fossil fuels to green energy.	
References	• Catalysis, Green Chemistry and Sustainable Energy: Editors: Angelo Basile, Gabriele Centi, Marcello Falco, Gaetano Iaquaniello; Hardcover ISBN: 9780444643377; eBook ISBN: 9780444643384. • Chemistry and Energy from Conventional to Renewable by Mark Anthony Benvenuto Publisher: De Gruyter ISBN: 9783110662269. • Solar to Chemical Energy Conversion ; Editors: Masakazu Sugiyama, Katsushi Fujii, Shinichiro Nakamura, DOI https://doi.org/10.1007/978-3-319-25400-5 Publisher: Springer Cham.	Minimum two references have to be provided along with the Year and Edition
Course Objective	The students will be benefited by learning: Gain a broad understanding of fundamental chemical principles. Gain insight into the applications in green chemistry and materials science Courses in areas related to physical chemistry, such as photochemistry, advanced electrochemistry, and courses in	List of items student should know on passing the course

	catalysis with a focus on renewable energy. These are needed for future research such as solar cells, batteries, and artificial photosynthesis.	
Justification:	Chemistry for Renewable Energy provides cutting-edge expertise through thorough research in this field. Research includes physical and chemical fundamentals that can participate in the development of new solutions for the sustainable production of electricity and fuels, and energy storage. Understanding the chemistry behind sustainable energy is critical in creating solutions to meet the world's future energy needs. The main objective is to demonstrate the breadth and depth of research being undertaken to address issues of sustainability and global energy demand. This course will provide a foundation of knowledge in the areas like nano-structured solar cells, artificial photosynthesis and solar fuels, photocatalysis, and Li-ion batteries etc and how to develop new solutions for sustainable production of electricity and fuels, as well as energy storage. No similar course is currently taught at IITH.	1) Philosophy of the course 2) If the course matches in content with another course, please provide comparison. Any two courses should not match largely

INDUSTRIAL PROCESSES

13. SE 50510 Net Zero Processes

Proposed New Course Template		
Fields	Values	Remarks
Date	Apr 2024	Course proposed date
Course Code	SE50510	In case of interdisciplinary course, it should be IDxxxx'.
Course Name	Net Zero Processes	
Credits	3	1, 2, 3, etc.
Pre-Requisites (if any)		Can be a Boolean Formula with ORs, ANDs and NOT (courses not to be taken along with this course)
Nature of Course	Theory	Theory, Lab, Design, Combined theory and lab, combined design and tutorial/lab, project /thesis, seminar
Type of Course	Elective	Core, Elective, interdisciplinary, etc.
Targeted Program and Year	M. Tech.	BTech (I, II, III or IV), B.Des, M.Sc, M.Tech, M.Des, MA, PhD, etc.

Contents	Define key terms relating to climate change and net zero carbon. Climate action and other latest global and local initiatives to mitigate the impacts of climate change Carbon Footprint Strategy and Energy Efficiency Green House Gas (GHG) emissions and the importance of this sector towards a net zero carbon future Carbon regulations (where carbon emissions can be minimized in the built environment through design, retrofit, and optimization of assets. Product Life Cycle Analysis and measuring standards	
References	• Moving Toward Net-Zero Carbon Society: Challenges and Opportunities, https://doi.org/10.1007/978-3-031-24545-9 • IEA, *Future of Petrochemicals*; IEA, Paris, 2018, https://www.iea.org/reports/the-future-of-petrochemicals (accessed on 2020/02/21). • Chapter 9 - Getting to net zero by 2050, https://doi.org/10.1016/B978-0-12-820308-8.00006-4	Minimum two references have to be provided along with the Year and Edition
Course Objective	This course provides essential knowledge and strategies for navigating environmental sustainability in the infrastructure sector, covering topics such as	List of items student should know on passing the course

	Zero, carbon neutrality, carbon offsetting, sustainable development goals and organisational readiness. It equips participants with the insights and tools needed to contribute actively to a sustainable and decarbonised future, making it suitable for a broad spectrum of individuals and professionals committed to addressing climate change and sustainability challenges.	
Justification:	No other similar courses in IITH.	1) Philosophy of the course 2) If the course matches in content with another course, please provide comparison. Any two courses should not match largely

14. SE 50520 Carbon Capture Utilization and Storage

Proposed New Course Template		
Fields	Values	Remarks
Date	Apr 2024	Course proposed date
Course Code	SE50520	In case of interdisciplinary course, it should be IDxxxx'.
Course Name	Carbon Capture Utilization and Storage	
Credits	3	1, 2, 3, etc.
Pre-Requisites (if any)		Can be a Boolean Formula with ORs, ANDs and NOT (courses not to be taken along with this course)
Nature of Course	Theory	Theory, Lab, Design, Combined theory and lab, combined design and tutorial/lab, project /thesis, seminar
Type of Course	Elective	Core, Elective, interdisciplinary, etc.
Targeted Program and Year	M. Tech.	BTech (I, II, III or IV), B.Des, M.Sc, M.Tech, M.Des, MA, PhD, etc.

Contents	Introduction to carbon capture, post-combustion capture, pre-combustion capture, CO_2 emission sources, point sources like coal, cement and petrochemicals, direct air capture, BECCS, current technologies for carbon capture, advanced techniques for carbon capture: adsorption-based carbon capture, membrane-based carbon capture; storage options including EOR, ECBMR, saline aquifers, basaltic formations; Utilization pathways including but not limited to green urea, building materials, food and beverages, chemicals and polymers. Laboratory sessions on surface area measurement, adsorption and membrane based separation.	
References	• J. Wilcox, Carbon Capture, Springer, 2012. • S.A. Rackley, Carbon capture and storage, Elsevier, 2009	Minimum two references have to be provided along with the Year and Edition
Course Objective	The objective of the course is to give an overview of the CCUS technology in terms of what are the methods and materials available for carbon capture, the different storage and utilization pathways.	List of items student should know on passing the course
Justification:	CCUS is an essential technology for achieving net zero emissions imperative for our climate mitigation efforts. There is no course currently running in IITH which offers a complete overview of the CCUS technology.	1) Philosophy of the course 2) If the course matches in content with another course, please provide comparison. Any two courses should not match largely
Justification:	No other similar courses in IITH.	1) Philosophy of the course 2) If the course matches in content with another course, please provide comparison. Any two courses should not match largely

15. SE 50540 Technologies for Sustainable Manufacturing

Proposed New Course Template		
Fields	Values	Remarks
Date	Apr 2024	Course proposed date
Course Code	SE50540	In case of interdisciplinary course, it should be IDxxxx'.
Course Name	Technologies for Sustainable Manufacturing	
Credits	1	1, 2, 3, etc.
Pre-Requisites (if any)	Nil	Can be a Boolean Formula with ORs, ANDs and NOT (courses not to be taken along with this course)
Nature of Course	Theory	Theory, Lab, Design, Combined theory and lab, combined design and tutorial/lab, project /thesis, seminar
Type of Course	Elective	Core, Elective, interdisciplinary, etc.
Targeted Program and Year	M. Tech.	BTech (I, II, III or IV), B.Des, M.Sc, M.Tech, M.Des, MA, PhD, etc.

Contents	Introduction to emerging technologies for sustainability - Technologies for new industrial revolutions - Digital Twin technologies, smart manufacturing. Advanced manufacturing technologies - laser-based technologies – 3D printing, additive manufacturing, laser marking, engraving, laser peening, laser-assisted machining, etc.,. for energy efficient manufacturing, Lean manufacturing.	
References	• Atkinson G, Dietz S, Neumayer E, "Handbook of sustainable manufacturing" Edward Elgar Publishing limited, 2007. • Dornfeld, David (Ed), " Green manufacturing : fundamentals and applications", Springer Science & Business Media,2012. • Klemes J, " Sustainability in the process industry", McGraw Hill,2011 • Avinash Kumar, Ashwani Kumar, Abhishek Kumar, Laser-based Technologies for Sustainable Manufacturing, CRC Press. 2023	Minimum two references have to be provided along with the Year and Edition
Course Objective	This course would equips students with knowledge, skills, and competencies to address environmental, social, and economic challenges in manufacturing processes and systems. The course would also provide insights into the new manufacturing technologies for sustainability. Students would also get to know the ways to optimize/tweak the manufacturing process to be energy efficient with reduced material wastage.	List of items student should know on passing the course

Justification:	No other similar courses in IITH.	1) Philosophy of the course 2) If the course matches in content with another course, please provide comparison. Any two courses should not match largely