MINOR DEGREES OFFERED UNDER SVEC-19 REGULATIONS

Offering Dept.	Title of the Minor	Students of Eligible Branches
CSE	Artificial Intelligence and Machine Learning	All branches except CSE, IT and CSSE
IT	Internet of Things	All branches except IT
CSSE	Cyber Security	All branches except CSE, IT and CSSE
ECE	VLSI and Embedded Systems	All branches except ECE
EEE	Power Systems and Drives	All branches except EEE
EIE	Instrumentation and Control Engineering	All branches except EIE
ME	Robotics	All branches except ME
CE	Sustainable Engineering	All branches except CE

Academic Regulations for Minor Degree:

The concept of Minor degree is introduced in the curriculum of all B.Tech. programs offering a Major degree. The main objective of Minor degree in a discipline is to provide additional learning opportunities for academically motivated students and it is an optional feature of the B.Tech. Program. To earn a Minor degree in a discipline, a student has to earn 18 extra credits (By studying FIVE theory & THREE laboratory courses or SIX Theory Courses) from the core courses of the minor discipline.

a. Students having a CGPA of 8.0 or above up to II B.Tech I-Semester without any backlogs shall be permitted to register for a Minor degree by paying the requisite fee.

b. In the subsequent semesters, the student has to pass all the courses registered for Major and Minor Degrees in the first attempt i.e., regular examinations without any backlog to keep the Minor Degree registration active or else it shall be cancelled.

c. If a student becomes ineligible for continuing the Minor Degree, the earned credits under Minor Degree cannot be transferred to Major

Degree; they will remain extra. These additional courses will be mentioned in the transcript. However, they are eligible to receive B.Tech. Degree after satisfying its requirements.

d. The evaluation pattern of the courses shall be similar to the evaluation of regular program courses.

e. Minimum strength required for offering Minor Degree in a discipline is 40 students.

f. A student registered for Minor degree shall pass in all subjects that constitute the requirement for the Minor degree program. No class/division (i.e., second class, first class and distinction, etc.) shall be awarded for Minor degree program.

g. The Minor degree shall be mentioned in the degree certificate as Bachelor of Technology in XXX with Minor in YYY. For example, Bachelor of Technology in Computer Science & Engineering with Minor in Title of the Minor Pursued. This shall also be mentioned in the transcripts, along with the list of courses taken for Minor degree program. However, the performance of the student in the Minor courses will not be considered for the calculation of SGPA and CGPA for the award of Major Degree.

h. Separate course/class work and time table shall be arranged for the various Minor degree programs. Attendance regulations for these Minor discipline programs shall be as per regular courses.

i. Students aspiring for Minor degree must register from III B.Tech I-Semester onwards and must opt for a Minor in a discipline other than the discipline he is registered in.

j. A Student shall register for Minor with the following combinations:

Offering Theory and Laboratory Courses: SEVEN credits in a semester starting from III B.Tech I-Semester to III B.Tech II-Semester (TWO theory & ONE laboratory courses) and FOUR credits in IV B.Tech I-Semester (ONE theory & ONE laboratory courses).

Offering Theory Courses only: SIX credits in a semester starting from III B.Tech I-Semester to IV B.Tech I-Semester (TWO theory courses).

NOTE: Interested meritorious students shall be permitted to register either for a Minor degree in a discipline (or) Honors Degree in a discipline only, but not both.

MINOR DEGREE IN

SUSTAINABLE ENGINEERING

Offering Department: CIVIL ENGINEERING

Students of Eligible Branches: CSE, CSSE, IT,ECE, EEE, EIE and ME

COURSE STRUCTURE

Year &Semester	Course Code	Course Title	Contact Periods per week				C	Scheme of Examination Max. Marks		
			L	T	P	Total		Int. Marks	Ext. Marks	Total Marks
III B.Tech. I-Sem (2 Theory)	19BM50101	Sustainable Engineering*	3	-	-	3	3	40	60	100
	19BM50102	Ecology and Environmental Impact	3	-	-	3	3	40	60	100
	19BM50103	Waste to Energy	3	-	-	3	3	40	60	100
III B.Tech. II-Sem (2 Theory)	19BM60101	Environmental Sustainability	3	-	-	3	3	40	60	100
	19BM60102	Sustainable Energy Systems	3	-	-	3	3	40	60	100
	19BM60103	Sustainability in The Built Environment	3	-	-	3	3	40	60	100
IV B.Tech. I-Sem (2 Theory)	19BM70101	Environmental Economics	3	-	-	3	3	40	60	100
	19BM70102	Sustainable Cities	3	-	-	3	3	40	60	100
	19BM70103	Sustainable Design of Technology Systems	3	-	-	3	3	40	60	100

*Compulsory Course if not studied in major degree

Note: If any student has chosen a course from the above list in their regular curriculum then, he/she is not eligible to opt the same course/s for the Minor degree. It is the responsibility of the student to acquire/complete prerequisite before taking the respective course.

III B. Tech. - I Semester

(19BM50101) **SUSTAINABLE ENGINEERING**

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: -

COURSE DESCRIPTION: Principles of sustainability; Sustainability metrics and assessment tools; Sustainable engineering practices; Sustainable engineering applications; Sustainable urbanization and industrialization.

COURSE OUTCOMES: *After successful completion of the course, students will be able to:*

CO1. Analyze the principles of sustainability to solve complex environmental problems following relevant standards/protocols considering society, health, safety and environment.

CO2. Analyze sustainability metrics and assessment tools to solve complex environmental problems following relevant standards and emerging trends considering society, health, safety, environment and economics besides communicating effectively in graphical form.

CO3. Analyze sustainable engineering practices to solve complex environmental problems using appropriate tools and techniques following relevant standards considering society, health, safety, environment, economics and management besides communicating effectively in graphical form.

CO4. Design sustainable engineering applications to solve complex environmental problems using appropriate tools and techniques following relevant standards considering society, health, safety, environment, economics and management besides communicating effectively in graphical form.

CO5. Analyze sustainable urbanization and industrialization principles to solve complex environmental problems using appropriate tools and techniques following relevant standards considering society, health, safety, environment, economics and management besides communicating effectively in graphical form.

Mapping of COs with POs and PSOs

Course Outcomes	Bloom's Level	Program Outcomes												Program Specific Outcomes		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	4	3	3		3		2	3	2							3
CO2	4	3	3		2	2	2	2	2		1	2	1			3
CO3	4	3	3		2	2	2	2	2		1	2				3
CO4	6	3	3	3	2	2	2	2	2		1	2				3
CO5	4	3	3		2	2	2	2	2		1	2				3
Average		3	3	3	2.2	2	2	2.2	2		1	2	1			3
Course Correlation Level		3	3	3	3	2	2	3	2		1	2	1			3

Correlation Levels: 3: High 2: Medium 1: Low

DETAILED SYLLABUS:

UNIT - I: PRINCIPLES OF SUSTAINABILITY (09 Periods)

Emerging challenges, Sustainability and sustainable engineering; Environmental concerns; Social, economic and legal issues; Availability and depletion of natural resources, Disaster resiliency; Multilateral environmental agreements – Basel convention, Clean development mechanism (CDM), Montreal and Kyoto protocols.

UNIT – II: SUSTAINABILITY METRICS AND ASSESSMENT TOOLS (09 Periods)

Sustainability indicators, metrics and assessment tools, Material flow analysis and material budget, Carbon footprint analysis, Life cycle assessment, Streamlined life-cycle assessment (SLCA), Economic input output-life cycle analysis, Environmental health risk assessment, Other emerging assessment tools.

UNIT - III: SUSTAINABLE ENGINEERING PRACTICES (09 Periods)

Sustainable energy engineering, Sustainable waste management, Green and sustainable buildings and infrastructure, Sustainable civil infrastructure, Sustainable remediation of contaminated sites, Climate geoengineering.

UNIT - IV: SUSTAINABLE ENGINEERING APPLICATIONS (09 Periods)

Environmental and chemical engineering projects, Materials engineering projects, Infrastructure engineering projects – Background, Methodology, Goal and Scope, Study area, Technical design, Environmental sustainability, Life cycle assessment, Economic sustainability, Social sustainability, Rating systems – ENVISION, LEED, GRIHA, IGBC; Conclusions.

UNIT – V: SUSTAINABLE URBANIZATION AND INDUSTRIALIZATION

(09 Periods)

Sustainable urbanization and industrialization, United Nations sustainable development goals – Right to education, Poverty eradication, Social and technological changes; Industrial Processes - Material selection, Energy efficiency, Pollution prevention and control techniques, Industrial Ecology, Industrial symbiosis.

Total Periods: 45

Topics for self-study are provided in the lesson plan.

TEXT BOOKS:

1. Reddy, K. R., Cameselle, C., and Adams, J. A., *Sustainable Engineering: Drivers, Metrics, Tools, and Applications*, John Wiley & Sons, Inc., Hoboken, New Jersey, 2019,
2. Allen, D. T. and Shonnard, D. R., *Sustainability Engineering: Concepts, Design and Case Studies*, Pearson Education, 1st Edition, 2012.

REFERENCE BOOKS:

1. Bradley. A. S; Adebayo, A. O., Maria, P., *Engineering Applications in Sustainable Design and Developmen*t, Cengage Learning, 1st Edition, 2016.
2. Purohit, S. S., *Green Technology: An Approach for Sustainable Environment*, Agrobios Publication, 1st Edition, 2016.
3. *Energy Conservation Building Code (ECBC) 2007*, Bureau of Energy Efficiency, Govt. of India, New Delhi.
4. Twidell, J. W. and Weir, A. D., *Renewable Energy Resources*, Routledge, Taylor & Francis Group, 3rd Edition, 2015.

ADDITIONAL LEARNING RESOURCES:

1. Daniel A. Vallero and Chris Brasier, *Sustainable Design: The Science of Sustainability and Green Engineering*, Wiley-Blackwell, 1st Edition, 2008.
2. Jorge A. Vanegas, *Sustainable Engineering Practice: An Introduction*, Committee on Sustainability, American Society of Civil Engineers, https://doi.org/10.1061/9780784407509, 2004.
3. Mackenthun, K. M., *Basic Concepts in Environmental Management*, CRC Press, Taylor & Francis Group, 1st Edition, 1999.
4. *Environment Impact Assessment Guidelines*, Notification of Government of India, 2006.

III B.Tech. - I Semester

(19BM50102) **ECOLOGY AND ENVIRONMENTAL IMPACT**

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PREREQUISITES: Course on Environmental Science

COURSE DESCRIPTION: Ecology; Ecosystem; Ecological impact assessment, Ecotoxicology and bio-monitoring, Restoration ecology.

COURSE OUTCOMES: *On successful completion of this course, the students will be able to:*

CO1 Demonstrate the basic knowledge on ecology to provide solutions to environmental problems using appropriate tools and techniques considering society, health, environment and sustainability besides communicating effectively in graphical form.

CO2 Analyze the ecosystems to solve environmental problems using appropriate tools and techniques considering society, health, safety, environment and sustainability besides communicating effectively in graphical form.

CO3 Analyze the ecological impact assessment to solve complex environmental problems using appropriate tools and techniques following relevant standards and norms considering society, health, safety, environment, sustainability and economics besides communicating effectively in graphical form.

CO4 Analyze the eco-toxicology effects and bio-monitoring of ecosystems to solve complex environmental problems using appropriate tools and techniques following relevant standards and norms considering society, health, safety, environment, sustainability and project management besides communicating effectively in graphical form.

CO5 Analyze ecology of disturbed ecosystems, reconstructions and restoration of natural ecosystems to solve complex environmental problems following relevant standards and latest developments considering society, health, safety, environment, sustainability and project management besides communicating effectively in graphical form.

Mapping of COs with POs and PSOs

Course Outcomes	Bloom's Level	Program Outcomes												Program Specific Outcomes		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3				2	3	3			1					3
CO2	4	2	3			2	3	3			1					3
CO3	4	2	3		2	2	3	3	1		1	1				3
CO4	4	2	3		2	2	3	3	2		1	1				3
CO5	4	2	3		2	2	3	3	2		1	1	1			3
Average		2.2	3		2	2	3	3	1.67		1	1	1			3
Course Correlation Level		3	3		2	2	3	3	2		1	1	1			3

Correlation Levels: 3: High 2: Medium 1: Low

DETAILED SYLLABUS:

UNIT - I: ECOLOGY (10 Periods)

Scope, concept and multidisciplinary nature of ecology; Organizational level of ecological systems, Abiotic and biotic environment, Limiting factors, Adaptation, Habitat and niche, Holocoenotic nature of environment, Concept of biosphere; Landscape, population and community ecology; Synecological principles, Species area relations, Methods of sampling and describing plant community, Ecological succession, Succession models, Concept of climax.

UNIT - II: ECOSYSTEM (08 Periods)

Structure and function of ecosystems, Productivity, Decomposition, Energy flow, Ecological efficiencies, Ecological pyramids, Global pattern of productivity, Nutrient cycling (Carbon, Nitrogen and Phosphorus), Ecosystem stability – Inertia, Resilience; Fragile ecosystem, Hot spots, Ecosystem services, Net Present Value (NPV) of ecosystems, Major biomes of India and the world.

UNIT - III: ECOLOGICAL IMPACT ASSESSMENT (09 Periods)

Principles and practices of ecological assessment, Carrying capacity of environment and earth, Environmental quality, Ecological and social impact of man, Resource depletion, Loss of biological diversity, Land degradation and deforestation, Impact assessment methods through case studies at organism, Community and ecosystem levels, Detailed criteria, Survey methods and evaluation, Cost benefit analysis, Prediction of impacts on physical environment and biotic communities through modelling, Developing impact statement.

UNIT - IV: ECOTOXICOLOGY AND BIO-MONITORING (08 Periods)

Ecotoxicology:Ecotoxicology - Background, importance and measurement; LC50, EC50, NOEC, LOEC, Toxic units, Ecosystem response to de-oxygenation; Eutrophication - Kinetics, Lake phosphorous model, Pesticides.

Bio-monitoring: Bio-monitoring, Active and passive monitoring, Concept of bioaccumulation, Bio-indicator parameters, Bio-air conditioning and bio-purifiers, Pollution tolerance index of plants, Green belt development, Plant protection and protective substances to pollution stress, Data-gathering techniques, Organization of the survey and data analysis.

UNIT - V: RESTORATION ECOLOGY (10 Periods)

Ecological theories and principles that guide restoration practices in a variety of ecosystems, Causes of ecosystem degradation, Motivations for restoration, Factors that influence success in restoration; Ecology of disturbed ecosystems - Disturbance and its impact on the structure and functioning of terrestrial and aquatic ecosystems; Aims and strategies of restoration - Concepts of restoration, Single vs. multiple end-points, Ecosystem reconstructions, Physical, chemical, biological and biotechnological tools of restoration; Restoration of biological diversity - Acceleration of ecological succession, Reintroduction of biota; Degradation and restoration of natural ecosystems – Rivers, Wetlands, Forests, Grassland, Savanna, Aquatic; Restoration of degraded soils - Restoration of contaminated soils and soil fertility, Mine spoil restoration.

Total Periods: 45

Topics for self-study are provided in the lesson plan.

TEXT BOOKS:

1. Saha, T. K., *Ecology and Environmental Biology*, Books and Allied (P) Ltd., Kolkata, 1st Edition, 2010.
2. Walker, C. H., Hopkin, S. P., Sibly R. M. and Peakall, D. B., *Principles of Ecotoxicology*, Taylor and Francis Group, London, 2nd Edition, 2004.
3. Palmer, M. A., Zedler, J. B. and Falk, D. A., *Foundations of Restoration Ecology*, Island Press, USA, 2016.

REFERENCE BOOKS:

1. Dash, M. C. and Dash, S. P., *Fundamentals of Ecology*, Tata - McGraw Hill, New Delhi, 3rd Edition, 2001.
2. Smith, T. M. and Smith, R. L., *Elements of Ecology*, Pearson Education Ltd., England, 9th Edition, 2015.
3. Hughes, W., *Essentials of Environmental Toxicology*, Taylor & Francis Press, USA, 2005.
4. Wathern, P., and Hynman, U., *Impact Assessment and Sustainable Resource Management-Theory and Practice*, Routledge Press, 2014.
5. Westman, W. E., Ecology, *Impact Assessment and Environmental Planning*, John Wiley, New York, 1985.

ADDITIONAL LEARNING RESOURCES:

1. Rajgopalan, R., *Environment and Ecology - A Complete Guide*, OakBridge Publishing, 2nd Edition, 2019.
2. Charles J. Krebs, *Ecology: The Experimental Analysis of Distribution and Abundance*, Pearson Education India, 6th Edition, 2008.
3. Mani, M., Ganesh, L.S. and Varghese, K., *Sustainability and Human Settlements*, Sage Publications, New Delhi, 1st Edition, 2005.

III B.Tech. - I Semester

(19BM50103) **WASTE TO ENERGY**

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Course on Environmental Science.

COURSE DESCRIPTION: Waste to energy concept; Municipal solid waste; Thermochemical waste to energy technologies; Biological waste to energy technologies; Waste to energy plants and the environment.

COURSE OUTCOMES: On successful completion of this course, the students will able to:

CO1 Analyze waste to energy process to solve waste management challenges using appropriate tools and techniques, following relevant codes, regulations and latest developments considering society, environment, sustainability and economics besides communicating effectively in graphical form.

CO2 Analyze municipal solid waste characteristics and sampling techniques to solve solid waste management challenges using appropriate tools and techniques, following relevant codes, regulations and latest developments considering society, environment, sustainability and economics besides communicating effectively in graphical form.

CO3 Analyze thermochemical waste to energy technologies to solve solid waste management challenges using appropriate tools and techniques, following relevant codes, regulations and latest developments considering society, environment, sustainability and economics besides communicating effectively in graphical form.

CO4 Analyze traditional and advanced biological technologies for converting waste to energy using appropriate tools and techniques, following relevant codes, regulations and latest developments considering society, environment, sustainability and economics besides communicating effectively in graphical form.

CO5 Analyze energy plants and the environment to solve waste to energy challenges using appropriate tools and techniques, following relevant codes, regulations and latest developments considering society, environment, sustainability and economics besides communicating effectively in graphical form.

Mapping of COs with POs and PSOs

Course Outcomes	Bloom's Level	Program Outcomes												Program Specific Outcomes		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	4	2	3			1	3	3	1		2	1	1			3
CO2	4	2	3			2	3	3	1		1	1	1			3
CO3	4	2	3			3	3	3	1		1	2	2			3
CO4	4	2	3			2	3	3	1		2	1	1			3
CO5	4	2	3			2	3	3	1		1	3	1			3
Average		2.00	3.00			2.00	3.00	3.00	1.00		1.40	1.60	1.20			3.00
Course Correlation Level		2	3			2	3	3	1.00		2	2	2			3

Correlation Levels: 3 – High 2 – Medium 1 – Low

DETAILED SYLLABUS:

UNIT - I: WASTE TO ENERGY CONCEPT (09 Periods)
Waste to energy- A historical prospective, Waste as a renewable resource, Global production of power from waste; The politics of waste - Waste management hierarchy, Circular economy/zero Waste, Energy from waste with the circular economy concept.

UNIT - II: MUNICIPAL SOLID WASTE (08 Periods)
Sources and types of solid waste, Quantity, Factors affecting generation of solid waste, Characteristics, Waste classification, Methods of sampling and characterization, Energy content of the waste.

UNIT - III: THERMOCHEMICAL WASTE TO ENERGY TECHNOLOGIES (10 Periods)
Traditional waste combustion technologies - Waste processing and treatment facility, Rotary combustors, Fluidized bed combustors; Energy production from waste through advanced thermochemical techniques - Incineration, Gasification and Pyrolysis.

UNIT - IV: BIOLOGICAL WASTE TO ENERGY TECHNOLOGIES (10 Periods)
Energy production from waste through biological techniques - Anaerobic digestion, Fermentation, Transesterification, Advanced microbial fuel cells; Cultivation of algal biomass from wastewater and energy production from algae.

UNIT - V: WASTE TO ENERGY PLANTS AND THE ENVIRONMENT (08 periods)
Emission limits for waste combustion, Environmental politics and science, Waste to energy plant cost, Latest developments in waste to energy, Case Studies.

Total Periods: 45

Topics for self-study are provided in the lesson plan.

TEXT BOOKS:

1. Breeze, Paul, *Energy from Waste*, Academic Press, 1st Edition, 2017.
2. Singh, R. P., Prasad, V. and Vaish, B., *Advances in Waste-to-Energy Technologies*, CRC Press, 1st Edition, 2019.

REFERENCE BOOKS:

1. Maczulak, A. E., *Environmental Engineering: Designing a Sustainable Future,* Infobase Publishing, 4th Edition, 2010.
2. Kalogirou, E. N., *Waste-to-Energy Technologies and Global Applications*, CRC Press, 1st Edition, 2017.
3. Klinghoffer, N. B., & Castaldi, M. J., *Waste to Energy Conversion Technology*, Elsevier, 3rd Edition, 2013.

ADDITIONAL LEARNING RESOURCES:

1. Rogoff, M. J., & Screve, F., *Waste-to-energy: Technologies and Project Implementation*, Academic Press, 1st Edition, 2019.
2. Trabold, T., and Babbitt, C. W., *Sustainable Food Waste-to-Energy Systems*, Academic Press, 1st Edition, 2018.

III B.Tech. - II Semester

(19BM60101) **ENVIRONMENTAL SUSTAINABILITY**

Int. Marks	Ext. Marks	Total	L	T	P	C
40	60	100	3	-	–	3

PREREQUISITES: Course on Environmental Science, Sustainable Engineering

COURSE DESCRIPTION: Environmental measurements from different disciplines and sustainability concepts; Environmental chemistry and physical process in environment; Environmental risk assessments with concepts of EIA and LCA; Sustainability assessment of water and wastewater treatment; Sustainability assessment of solid waste management and air pollution issues.

COURSE OUTCOMES: On successful completion of this course, the students will be able to:

CO1 Analyze environmental measurements and sustainability concepts to solve environmental sustainability challenges using appropriate tools and techniques, following relevant codes, regulations and latest developments considering society, environment, sustainability and economics besides communicating effectively in graphical form.

CO2 Analyze environmental chemistry and physical processes to solve environmental sustainability challenges using appropriate tools and techniques, following relevant codes, regulations and latest developments considering society, environment, sustainability and economics besides communicating effectively in graphical form.

CO3 Analyze environmental risk assessment with concepts of EIA and LCA to solve environmental sustainability problems using appropriate tools and techniques following relevant codes and latest developments considering society, environment, sustainability and economics besides communicating effectively in graphical form.

CO4 Analyze water and wastewater treatment to solve environmental sustainability problems using appropriate tools and techniques, following relevant codes, regulations and latest developments considering health, society, environment, sustainability and economics besides communicating effectively in graphical form.

CO5 Analyze sustainable assessment of solid waste management and air pollution issue to solve complex problems using appropriate tools and techniques, following relevant codes, regulations and latest developments considering health, society, environment, sustainability and economics besides communicating effectively in graphical form.

Mapping of COs with POs and PSOs

Course Outcomes	Bloom's Level	Program Outcomes												Program Specific Outcomes		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	4	2	3			1	3	3	1		2	2	1			3
CO2	4	2	3			2	3	3	1		1	2	1			3
CO3	4	2	3			3	3	3	1		1	2	2			3
CO4	4	2	3			2	3	3	2		2	2	1			3
CO5	4	2	3			1	3	3	2		1	2	1			3
Average		2.00	3.00			2.00	3.00	3.00	1.40		1.40	2.00	1.20			3.00
Course Correlation Level		2	3			2	3	3	2		2	2	2			3

Correlation Levels: 3 – High 2 – Medium 1 - Low

DETAILED SYLLABUS:

UNIT – I: ENVIRONMENTAL MEASUREMENTS FROM DIFFERENT DISCIPLINES AND SUSTAINABILITY CONCEPTS (09 Periods)

Environmental measurements - Mass concentration units, Partial pressure units, Other types of units, Qualitative and quantitative measurements; Sustainability concepts and evolution, Engineering for sustainability.

UNIT – II: ENVIRONMENTAL CHEMISTRY AND PHYSICAL PROCESS IN ENVIRONMENT (09 Periods)

Environmental chemistry, Mass balance and reactor systems; Mass balance in continuous reactor, continuous stirred tank reactor (CSTR) and Plug flow reactor; Plug flow reactor and energy flow, Energy balance and earth overshot day, Mass transport processes.

UNIT – III: ENVIRONMENTAL RISK ASSESSMENT WITH CONCEPTS OF EIA AND LCA (09 Periods)

Life Cycle Assessment (LCA); Environmental Impact Assessment (EIA) - Fundamentals, Evolution of EIA (Global and Indian Scenario), Elements of EIA– Screening, Scoping, Public consultation, Environmental clearance process in India - Key elements in 2006 EIA (Govt. of India) notification; Environmental risk, Environmental impact calculation by using LCA technique, Risk assessments with concepts of EIA and LCA, Case studies.

UNIT – IV: SUSTAINABILITY ASSESSMENT OF WATER AND WASTEWATER TREATMENT (08 Periods)

Sustainability assessment in Water purification – Processes, Engineered systems – Aeration, Solids separation, Settling operations, Coagulation, Softening, Filtration, Disinfection; Sustainability assessment in wastewater treatment process and disposal – Primary, Secondary and Tertiary.

UNIT – V: SUSTAINABILITY ASSESSMENT OF SOLID WASTE MANAGEMENT AND AIR POLLUTION ISSUES (10 Periods)

Sustainability assessment of solid waste management –Need and scope; Municipal solid waste – Types, Composition and characteristics; Methods of collection and transportation; Methods of disposal – Open dumping, Sanitary landfill, Composting and

Incineration; Utilization - 6R Concept; Sustainability assessment of air pollution issues – Need and scope, Classification, Sources – Line, Area, Stationary, Mobile; Effects of air pollutants on man, Material and vegetation; Global effects of air pollution.

Total Periods: 45

Topics for self-study are included in the lesson plan.

TEXT BOOKS:

1. Davis, M. L. and Cornwell, D. A., *Introduction to Environmental Engineering,* McGraw-Hill, 5th Edition, 2008.
2. Keong, Choy Yee, *Global Environmental Sustainability: Case Studies and Analysis of the United Nations' Journey toward Sustainable Development*, Elsevier, 2020.

REFERENCE BOOKS:

1. Singh, Ritu, and Sanjeev Kumar, *Green Technologies and Environmental Sustainability*, Springer, 2nd Edition, 2017.
2. Joumard, Robert, and Henrik Gudmundsson, *Indicators of Environmental Sustainability in Transport: An Interdisciplinary Approach to Methods,* European Commission, 2nd Edition, *2010.*
3. Smith, Fraser, *Environmental Sustainability: Practical Global Applications*, CRC Press, 1st Edition, 2020.

ADDITIONAL LEARNING RESOURCES:

1. Burke, G., Singh,B. R. and Theodore, L., Handbook of Environmental Management and Technology, John Wiley & Sons, 2nd Edition, 2000.
2. Peavy, Howard S., Donald R. Rowe, and George Tchobanoglous, Environmental Engineering, McGraw-Hill, Indian Edition, 1st Edition, 2017.

III B.Tech. - II Semester

(19BM60102) **SUSTAINABLE ENERGY SYSTEMS**

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PREREQUISITES: Courses on Environmental Science, Sustainable Engineering

COURSE DESCRIPTION: The energy landscape and sustainability; Solar and wind energy; Biomass, geothermal, tidal and wave energies; Electricity storage technologies;Grid integration of renewable energy.

COURSE OUTCOMES: On successful completion of this course, the students will be able to:

CO1 Analyze the energy landscape and sustainability to provide solutions to energy problems using appropriate tools and techniques following relevant standards considering society, health and environment besides communicating effectively in graphical form.

CO2 Analyze solar and wind energy systems to solve the complex energy problems using appropriate tools and techniques following relevant standards considering society, health, environment, sustainability and economics besides communicating effectively in graphical form.

CO3 Analyze biomass, geothermal, tidal and wave energy systems to solve the complex energy problems using appropriate tools and techniques following relevant standards considering society, health, environment, sustainability and economics besides communicating effectively in graphical form.

CO4 Analyze electric storage technology systems to solve the complex energy problems using appropriate tools and techniques following relevant standards and latest developments considering society, health, environment, sustainability and economics besides communicating effectively in graphical form.

CO5 Analyze grid integration of renewable energy to solve the complex energy problems using appropriate tools and techniques following relevant standards considering society, health, environment, sustainability and economics besides communicating effectively in graphical form.

Mapping of COs with POs and PSOs

Course Outcomes	Bloom's Level	Program Outcomes												Program Specific Outcomes		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	4	2	3		1	2	3	3	1		1					3
CO2	4	2	3		1	2	3	3	1		1	2				3
CO3	4	2	3		1	2	3	3	1		1	2				3
CO4	4	2	3		1	2	3	3	1		1		2			3
CO5	4	2	3		1	2	3	3	1		1					3
Average		2	3		1	2	3	3	1		1	2				3
Course Correlation Level		2	3		1	2	3	3	1		1	2	2			3

Correlation Levels: 3: High 2: Medium 1: Low

DETAILED SYLLABUS:

UNIT - I: THE ENERGY LANDSCAPE AND SUSTAINABILITY (09 Periods)

Current global energy use, National and international energy consumption and related greenhouse gas emissions, Lifetime of fossil fuels, Sustainability and energy use, Energy conversion technologies, Energy forms and conversion, First and second laws of thermodynamics and efficiencies; Devices - Heat engines, Refrigerators, Heat pumps; Instantaneous and average power.

UNIT - II: SOLAR AND WIND ENERGY (09 Periods)

Principles of solar radiation, Resource foundations, Technology challenges, Sustainability, Solar energy industry and economics, Net Metering; Origin of the wind, Power in the wind, Wind resource basics, Wind energy technologies, Challenges, Sustainability, Wind energy Industry.

UNIT - III: BIOMASS, GEOTHERMAL, TIDAL AND WAVE ENERGIES (09 Periods)

Sources of feedstocks; Biofuels - Bioethanol, Biodiesel, Algal, Jatropha and Biogas; Conversion technology, Diesel and ethanol, Biogas, Electricity production, Transportation, Challenges, Sustainability, Economics; Geothermal energy - Principles, Geothermal potential and technology, Electricity production, Conversion technology, Challenges, Economics; Tidal and wave energies, Conversion technologies, Sustainability.

UNIT - IV: ELECTRICITY STORAGE TECHNOLOGIES (09 Periods)

Introduction, Battery energy storage technologies - Lithium-ion batteries, Full cells, Nickel-based batteries, Lead-acid batteries, Sodium-sulfur batteries; Hydro energy storage - Applications of pump hydro energy storage plant, Site selection for pump hydro energy storage plant; Thermal energy storage, Capacitors and applications, Latest developments.

UNIT - V: GRID INTEGRATION OF RENEWABLE ENERGY (09 Periods)

Variability, Intermittency and dispatchability, Electric grid infrastructure, Integrating renewable energy into the grid, Growing a more efficient grid, The smart grid, Secure communication in the smart grid; Cogeneration plant and power distribution in industry, Micro grids.

Total Periods: 45

Topics for self-study are provided in the lesson plan.

TEXT BOOKS:

1. Boyle, Godfrey, *Renewable Energy: Power for a Sustainable Future*, Oxford University Press, 3rd Edition, 2012.
2. Jefferson W. Tester, Elisabeth M. Drake, Michael J. Driscoll, Michael W. Golay, William A. Peters, *Sustainable Energy (Choosing Among Options)*, MIT Press, 2nd Edition, 2012.

REFERENCE BOOKS:

1. Gilbert M. Masters, *Renewable and Efficient Electric Power Systems*, John Wiley &Sons, Inc., Hoboken, New Jersey, 2nd Edition, 2013.
2. Vanek, F.M., Albright, L.D., *Energy Systems Engineering - Evaluation and Implementation*, McGraw-Hill, 2nd Edition, 2008.
3. David MacKay, *Sustainable Energy: Without the Hot Air*, UIT Cambridge Ltd., Cambridge, England, 2009.
4. Frank Kreith, *Principles of Sustainable Energy Systems*, , CRC Press, Taylor and Francis group, 2nd Edition, 2014.

ADDITIONAL LEARNING RESOURCES:

1. Richter Burton, *Beyond Smoke and Mirrors: Climate Change and Energy in the 21st Century*, Cambridge University Press, New York, 2010.

III B.Tech. - II Semester

(19BM60103) **SUSTAINABILITY IN THE BUILT ENVIRONMENT**

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Courses on Environmental Science, Sustainable Engineering.

COURSE DESCRIPTION: Sustainable urban development; Sustainable site planning and analysis; Sustainable buildings; Building envelope and services;Management of sustainable built environment.

COURSE OUTCOMES: On successful completion of this course, the students will be able to:

CO1 Analyze sustainable urban development to solve problems associated with the built environment using appropriate tools and techniques following relevant standards considering society, health and environment besides communicating effectively in graphical form.

CO2 Analyze sustainable site planning to solve complex problems associated with the built environment using appropriate tools and techniques following relevant standards considering society, health and environment besides communicating effectively in graphical form.

CO3 Analyze sustainable buildings to solve complex problems associated with the built environment using appropriate tools and techniques following relevant standards considering society, health and environment besides communicating effectively in graphical form.

CO4 Analyze building envelope and services to solve complex problems associated with the built environment using appropriate tools and techniques following relevant standards considering society, health and environment besides communicating effectively in graphical form.

CO5 Analyze management of sustainable built environment to solve complex problems using appropriate tools and techniques following relevant standards considering society, health and environment besides communicating effectively in graphical form.

Mapping of COs with POs and PSOs

Course Outcomes	Bloom's Level	Program Outcomes												Program Specific Outcomes		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	4	2	3		1	2	3	3	1		1					3
CO2	4	2	3		1	2	3	3	1		1					3
CO3	4	2	3		1	2	3	3	1		1					3
CO4	4	2	3		1	2	3	3	1		1					3
CO5	4	2	3		1	2	3	3	1		1	2				3
Average		2	3		1	2	3	3	1		1	2				3
Course Correlation Level		2	3		1	2	3	3	1		1	2				3

Correlation Levels: 3: High 2: Medium 1: Low

DETAILED SYLLABUS:

UNIT-I: SUSTAINABLE URBAN DEVELOPMENT (09 Periods)

Urban development - Human activities and their effects; Carbon cycle; Role of construction material such as concrete and steel; CO2 contribution from cement and other construction materials; GHG emissions - Global climate change; Efforts in sustainable development and construction - Universal efforts, International organizations involved.

UNIT - II: SUSTAINABLE SITE PLANNING AND ANALYSIS (09 Periods)

Sustainable site planning, Principles of site analysis, Improving sustainability of a site – Stormwater, Reducing site disturbance, Vegetation; Site analysis - Examples of site analysis; Introduction to alternative energy - Solar, Wind, Hydro, Biofuel etc.

UNIT - III: SUSTAINABLE BUILDINGS (09 Periods)

Introduction to sustainable buildings and standards, Green buildings, Energy efficiency and sustainability; Passive House; Net Zero Energy Buildings (NZEB), Examples of different types of NZEB.

UNIT - IV: BUILDING ENVELOPE AND SERVICES (09 Periods)

Building envelope effect and energy efficiency measures, Renewable energy integration, Sustainable building services, Sustainable construction and materials, Integrated design, Energy use and CO2, Built environment - Aging and susceptibility to natural disasters.

UNIT – V: MANAGEMENT OF SUSTAINABLE BUILT ENVIRONMENT (09 Periods)

Life cycle planning, Measuring sustainability; Facilities management - Waste management, Improved amenities,Improved transport infrastructure, Social mix, Accessibility issues, Cultural and historical issues.

Total Periods: 45

Topics for self-study are provided in the lesson plan.

TEXT BOOKS:

1. Alison Cotgrave and Mike Riley, *Total Sustainability in the Built Environment*, Macmillan Education, 1st Edition, 2012.
2. Kevin Lynch and Gary Hack, *Site Planning*, MIT Press, 3rd Edition, 1984.

REFERENCE BOOKS:

1. William McLean and Pete Silver, *Environmental Design Source Book: Innovative Ideas for a Sustainable Built Environment*, RIBA Publishing, 1st Edition, 2021.
2. Tim Dixon, John Connaughton, Stuart Green, *Sustainable Futures in the Built Environment to 2050: A Foresight Approach to Construction and Development*, John Wiley & Sons Ltd., 2018.
3. Rob Fleming, Saglinda H Roberts, *Sustainable Design for the Built Environment*, Routledge Press, London, 1st Edition, 2019.
4. Charles J. Kibert, *Sustainable Construction: Green Building Design and Delivery,* Wiley,4th Edition, 2021.

ADDITIONAL LEARNING RESOURCES:

1. Mani, M., Ganesh, L.S. and Varghese, K., *Sustainability and Human Settlements,* Sage Publications, 1st Edition, 2005.
2. Barton, H., Grant, M., Guise, R., *Shaping Neighbourhoods: For Local Health and Global Sustainability*, Routledge Press, 2nd Edition, 2020.
3. https://nptel.ac.in/courses/105/102/105102195/
4. https://nptel.ac.in/courses/124/107/124107011/

IV B.Tech. - I Semester

(19BM70101) **ENVIRONMENTAL ECONOMICS**

Int. Marks	Ext. Marks	Total	L	T	P	C
40	60	100	3	-	–	3

PREREQUISITES: Courses on Environmental Science, Sustainable Engineering.

COURSE DESCRIPTION: Fundamentals of environmental economics; Economy and the natural environment interaction; Economic development and environment; Valuation of environmental goods and services; Sustainable economic development.

COURSE OUTCOMES: On successful completion of this course, the students will able to:

CO1 Analyze fundamentals of environmental economics to solve environmental economics challenges associated with sustainable design of technology systems considering latest developments, society, environment, economic, and sustainability besides communicating effectively in graphical form.

CO2 Analyze economy and the natural environment interaction to solve ecological limits and scarcity of eco-services approaches using different tools and techniques considering latest developments, relevant guidelines, environment and sustainability besides communicating effectively in graphical form.

CO3 Analyze economic development and environment to solve environmental cost-benefit challenges using different tools and techniques considering latest developments, relevant guidelines, environment and sustainability besides communicating effectively in graphical form.

CO4 Analyze valuation of environmental goods and services to solve methodical challenges using different tools and techniques considering latest developments, relevant guidelines, environment and sustainability besides communicating effectively in graphical form.

CO5 Analyze sustainable economic development to solve environmental economics challenges using different tools and techniques considering latest developments, relevant guidelines, environment and sustainability besides communicating effectively in graphical form.

Mapping of COs with POs and PSOs

Course Outcomes	Bloom's Level	Program Outcomes												Program Specific Outcomes		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	4	2	3				3	3	2		1	3	1			3
CO2	4	2	3			1	3	3	2		1	3	1			3
CO3	4	2	3			1	3	3	1		2	3	1			3
CO4	4	2	3			1	3	3	1		1	3	1			3
CO5	4	2	3			1	3	3	2		2	3	1			3
Average		2.00	3.00			1.00	3.00	3.00	1.60		1.40	3.00	1.00			3.00
Course Correlation Level		2	3			1	3	3	2		2	3	1			3

Correlation Levels: 3:High 2: Medium 1:Low

DETAILED SYLLABUS:

UNIT – I: FUNDAMENTALS OF ENVIRONMENTAL ECONOMICS (10 Periods)

Fundamentals of environmental economics, Review of microeconomics and welfare economics, Ecology-economy interaction, Perspective of economic modeling- the concept and conditions of sustainability of the human economy, Classification and characterization of resources and pollution as a public good or bad, Role of Externalities as the fundamental determinants, Property Rights, Market, Spatial-temporal dimensions of externality- command and control, Market approaches, Green tax, Taxes in controlling externalities

UNIT - II: ECONOMY AND THE NATURAL ENVIRONMENT INTERACTION (08 Periods)

An overview of the economy and the natural environment; Interaction using an input-output based general equilibrium approach to show how ecological limits and scarcity of eco-services would affect the resource allocation and prices; Regimes of natural resources, Types of goods, Provision of public goods.

UNIT – III: ECONOMIC DEVELOPMENT AND ENVIRONMENT (09 Periods)

The relation between development environmental Quality - Environmental Kuznets curve; Development vs conservation of environmental resources - Ecosystem flips and irreversibility - Krutilla-Fisher equation; Environmental cost-benefit analysis under strong and weak conditions of sustainability; Choice of time discount rate for evaluation - Sustainability premium.

UNIT – IV: VALUATION OF ENVIRONMENTAL GOODS AND SERVICES (10 Periods)

Theory of environmental valuation and conceptual basis of its methods - Compensating variations and surplus, Equivalent variations and surplus, Willingness to pay or accept for improvement or loss of environmental goods and services; Empirical approaches in environmental valuation; Indirect methods of environmental valuation, Non-demand function methods of valuation, Revealed preference methods - (a) Hedonic Pricing, (b) Household production function approach, Defensive cost, Health cost and travel cost methods; The direct method of environmental valuation - Stated preference - Contingent valuation method.

UNIT – V: SUSTAINABLE ECONOMIC DEVELOPMENT (08 Periods)

Capital theoretic basis of the notion of sustainable development - Sustainable Development as non-declining intertemporal utility or that of the value of the wealth. Concepts of Genuine investment or savings, Green National Income, Natural capital stock and sustainable resource accounting, Strong and weak sustainability, Environmental adjustment of national income.

Total Periods: 45

Topics for self-study are included in the lesson plan.

TEXT BOOKS:

1. Siebert, H. and Siebert, H., *Economics of the Environment*. Massachusetts: Lexington Books, 9th Edition, 1981.
2. Pearce, David W., and Kerry Turner R., *Economics of Natural Resources and The Environment,* JHU Press, Revised and Enlarged Edition, 1990.

REFERENCE BOOKS:

1. Nick Hanley, Jason F Shorgen and Ben White, *Environmental Economics Theory and Practice*, MacMillan, 2nd Edition, 2006.
2. Tietenberg, Tom and Lynne Lewis, *Environmental and Natural Resource Economics*, Routledge, 11th Edition, 2018.
3. Kumar, P., *The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations*, Routledge, 2012.

ADDITIONAL LEARNING RESOURCES:

1. Field, C., *Environmental Economics: An Introduction*, McGraw-Hill Book Company (UK) Ltd, 8th Edition, 2021.
2. Sengupta, R., *Ecological Limits and Economic Development,* OUP Catalogue, 2013.

IV B.Tech. - I Semester

(19BM70102) **SUSTAINABLE CITIES**

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Courses on Environmental Science, Sustainable Engineering.

COURSE DESCRIPTION: Sustainability and urban development; Functions of cities; Inclusive, Safe and productive cities; Sustainable urban services and infrastructure; Governing sustainable cities.

COURSE OUTCOMES: On successful completion of this course, the students will able to:

CO1 Analyze sustainability and urban development to solve problems associated with cities using appropriate tools and techniques following relevant codes, regulations and latest developments considering society, environment, sustainability and economics besides communicating effectively in graphical form.

CO2 Analyze city functioning for sustainability to solve problems associated with cities using appropriate tools and techniques, following relevant codes, regulations and latest developments considering society, environment, sustainability and economics besides communicating effectively in graphical form.

CO3 Analyze inclusiveness, safety and productivity in cities to solve problems associated with cities using appropriate tools and techniques, following relevant codes, regulations and latest developments considering society, environment, sustainability and economics besides communicating effectively in graphical form.

CO4 Analyze sustainable urban services and infrastructure to solve problems associated with cities using appropriate tools and techniques, following relevant codes, regulations and latest developments considering society, environment, sustainability and economics besides communicating effectively in graphical form.

CO5 Analyze governance for sustainable cities to solve problems associated with cities using different tools and techniques considering latest developments, relevant guidelines, environment and sustainability besides communicating effectively in graphical form.

Mapping of COs with POs and PSOs:

Course Outcomes	Bloom's Level	Program Outcomes												Program Specific Outcomes		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	4	2	3			1	3	3	2		1	1	1			3
CO2	4	2	3			1	3	3	3		1	2	1			3
CO3	4	2	3			1	3	3	2		1	2	1			3
CO4	4	2	3			1	3	3	2		1	1	1			3
CO5	4	2	3			1	3	3	3		1	2	1			3
Average		2.00	3.00			1.00	3.00	3.00	2.40		1.00	1.60	1.00			3.00
Course Correlation Level		2	3			1.00	3.00	3.00	3		1	2	1.00			3.00

Correlation Levels: 3 – High 2 – Medium 1 - Low

DETAILED SYLLABUS:

UNIT - I: SUSTAINABILITY AND URBAN DEVELOPMENT (08 Periods)
The urban opportunity; Cities - Cultural and social transformation; Challenge of urban politics, Planning and governance, Urban research methods, Urban theory and history, Urban development and the environment, Urban growth and the environment - Why cities grow?, Externalities and the environment, Urban economic restructuring, City size and settlement planning.

UNIT - II: FUNCTIONS OF CITIES (09 Periods)
Understanding urban systems, Municipal, Regional and national governance, Urban utilities, Urban public finance and taxation; Law, order and conflict; Land management and planning, Lessons from London and Mumbai.

UNIT - III: INCLUSIVE, SAFE AND PRODUCTIVE CITIES (10 Periods)
What is urban poverty?, Measuring urban poverty, Poverty reduction in cities, Affordable and adequate housing, Who can deliver the housing we need?, Safety and violence, Urban vulnerabilities; Making cities productive and reduce inequality- City production and consumption, Women in the informal economy, Migration, mobility and the urban-rural continuum Wealth and inequality, Case: SEWA, India, Migration and the refugee crisis; Improving human development in cities – Addressing the challenges of urban public health, Solutions for improving urban health, Education and skills, Higher education in cities, Gender in the city, Human rights and justice, Law and equality, Apartheid in South African cities.

UNIT - IV: SUSTAINABLE URBAN SERVICES AND INFRASTRUCTURE (08 Periods)
Sustainable environmental services and infrastructure, Sustainable transport planning, ICT, Sustainable urban energy systems, Sustainable transport: Bangkok; How can cities be resilient -Air, water, food and natural resources; City risk exposure; Climate impacts, adaptation and mitigation; Building urban resilience, Environmental planning and the politics of change.

UNIT - V: GOVERNING SUSTAINABLE CITIES (10 periods)
Sustainable environmental practices, Urban disaster risk management, Post-disaster recovery, SDGs and other global processes, New institutions and governance, Public participation and democracy, Financing sustainable development, Measuring and monitoring the SDGs, Opportunities of secondary cities.

Total Periods: 45

Topics for self-study are included in the lesson plan.

TEXT BOOKS:

1. Al-Zu'bi, Maha, and Vesela Radovic, *SDG11-Sustainable Cities and Communities: Towards Inclusive, Safe, and Resilient Settlements*, Emerald Group Publishing, 1st Edition, 2019.
2. Rydin, Yvonne, *Governing for Sustainable Urban Development*, Earthscan, 2012.
3. Evans, Bob, Marko Joas, Susan Sundback, and Kate Theobald, *Governing Sustainable Cities*, Routledge, 2013.

REFERENCE BOOKS:

1. Register, R., EcoCities: *Rebuilding Cities in Balance with Nature*, New Society Publishers, Revised Edition, 2006.
2. Yigitcanlar, T, *Sustainable Urban and Regional Infrastructure Development: Technologies, Applications and Management: Technologies, Applications and Management*, IGI Global, 2007.

ADDITIONAL LEARNING RESOURCES:

1. Flint J. and Raco M., *The Future of Sustainable Cities: Critical Reflections,* Policy Press, 2nd Edition, 2012.
2. Corburn, J., *Toward the Healthy City: People, Places and the Politics of Urban Planning,* MIT Press, 3rd Edition, 2009.

IV B.Tech. - I Semester

(19BM70103) **SUSTAINABLE DESIGN OF TECHNOLOGY SYSTEMS**

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	--	--	3

PRE-REQUISITES: Courses on Environmental Science, Sustainable Engineering.

COURSE DESCRIPTION: Sustainability and sustainable development; Product life cycle design – Methods and strategies; Product life cycle design – Software tools; Designing for sustainable product-service system – Methods and tools; Design for sustainability – Engineering design criteria and guidelines.

COURSE OUTCOMES: On successful completion of this course, the students will able to:

CO1 Analyze sustainability and sustainable development to solve complex problems associated with sustainable design of technology systems using appropriate tools and techniques, following relevant codes, regulations and latest developments considering society, environment and economics besides communicating effectively in graphical form.

CO2 Analyze product life cycle design methods and strategies to solve complex problems associated with sustainable design of technology systems using appropriate tools and techniques, following relevant codes, regulations and latest developments considering society, environment and economics besides communicating effectively in graphical form.

CO3 Analyze product life cycle design software tools to solve complex problems associated with sustainable design of technology systems using appropriate tools and techniques, following relevant codes, regulations and latest developments considering society, environment and economics besides communicating effectively in graphical form.

CO4 Design sustainable product-service systems to solve complex problems associated with sustainable design of technology systems using appropriate tools and techniques, following relevant codes, regulations and latest developments considering society, environment and economics besides communicating effectively in graphical form.

CO5 Design engineering criteria and guidelines to solve complex problems associated with sustainable design of technology systems using appropriate tools and techniques, following relevant codes, regulations and latest developments considering society, environment and economics besides communicating effectively in graphical form.

Mapping of COs with POs and PSOs:

Course Outcomes	Bloom's Level	Program Outcomes												Program Specific Outcomes		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	4	2	3			2	3	3	1		1	1	1			3
CO2	4	2	3			2	3	3	1		1	1	1			3
CO3	4	2	3			3	3	3	2		2	1	2			3
CO4	6	1	2	3	2	3	3	3	1		1	1	1			3
CO5	6	1	2	3	2	2	3	3	1		1	2	1			3
Average		1.60	2.60	3.00	2.00	2.40	3.00	3.00	1.20		1.20	1.20	1.20			3.00
Course Correlation Level		2	3	3	2	3	3	3	2		2	2	2			3.00

Correlation Levels: 3 – High 2 – Medium 1 - Low

DETAILED SYLLABUS:

UNIT - I: SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT (09 Periods)
Sustainability and sustainable development - Understanding un-sustainability and need for Sustainability, Definitions, Pathway, Systems approach to design; Evolution of sustainability within design - Diverse approaches to design for sustainability, Relationship between approaches to design for sustainability and the application context.

UNIT - II: PRODUCT LIFE CYCLE DESIGN – METHODS AND STRATEGIES (08 Periods)
Life Cycle Assessment (LCA) - Product Life Cycle Assessment, LCA introduction, LCA methodology, LCA goal, LCA scope, Inventory analysis, Impact assessment, Interpretation; Environmental risk, Environmental impacts calculation by using LCA technique, Risk assessment with concepts of LCA.

UNIT - III: PRODUCT LIFE CYCLE DESIGN – SOFTWARE TOOLS (08 Periods)
History of product design by LCA with examples; ISO 14000, Life cycle analysis, SIMA PRO, LCA software and other software for LCA, LCA methodical challenges - Allocation and uncertainty, Sensitivity analysis.

UNIT - IV: DESIGNING FOR SUSTAINABLE PRODUCT-SERVICE SYSTEM – METHODS AND TOOLS (10 Periods)
Sustainable product service system design – Definition, Types and examples; Sustainable product service system – Transition path and challenges, Sufficiency economy philosophy applied to sustainable product-service system (PSS) thinking, Khadi movement as a precursor to PSS thinking.

UNIT - V: DESIGN FOR SUSTAINABILITY – ENGINEERING DESIGN CRITERIA AND GUIDELINES (09 periods)
Sustainable product-service system design applied to distributed economy, Other design for sustainability tools and approaches – Agriculture, Cities and communities, Carbon footprint, Green buildings, Green materials, Green energy, Sustainable development, Zero waste, Circular economy.

Total Periods: 45

Topics for self-study are provided in the lesson plan.

TEXT BOOKS:

1. Horne, Ralph, Tim Grant, and Karli Verghese, *Life Cycle Assessment: Principles, Practice and Prospects*, Csiro Publishing, 2009.
2. Bhamra, Tracy, and Vicky Lofthouse, *Design For Sustainability: A Practical Approach*. Routledge, 1st Edition, 2016.

REFERENCE BOOKS:

1. Vezzoli, C., Kohtala, C., Srinivasan, A., Diehl, J. C, Fusakul, S. M., Xin, L. and Sateesh, D., Product-service System Design for Sustainability, Routledge, 1st Edition, 2017.
2. Curran, Mary Ann, *Life Cycle Assessment Student Handbook*, John Wiley & Sons, 1st Edition, 2015.
3. Hauschild, Michael Z., Ralph K. Rosenbaum and Stig Irvin Olsen, *Life Cycle Assessment*, Springer International Publishing, 2018.
4. Hendrickson, Chris T., Lester B. Lave, and H. Scott Matthews, *Environmental Life Cycle Assessment of Goods and Services: An Input-Output Approach*. Routledge, 2010.

ADDITIONAL LEARNING RESOURCES:

1. Sharmistha Banerjee, System Design for Sustainability, IIT Guwahati, https://nptel.ac.in/ courses/107/103/107103081/.
2. Curran, Mary Ann, *Life Cycle Assessment Handbook: A Guide for Environmentally Sustainable Products*, John Wiley & Sons, 3rd Edition, 2012.