Semester- III

	GENERATIVE URBAN DESIGN AND SMART CITY DYNAMICS			
	Course Code	2MDAC301	CIE Marks	50
	Teaching Hours per semester (L:T:S)	14:14:70	Viva Marks	50
	Total Hours of Pedagogy	240 Hours	Total Marks	100
	Credits	8	Exam Hours	-

Course Learning objectives:

To explore new limits, systemic complexities, and opportunities of urban interventions that are assisted by parametric design principles and smart city tracking. The aim is to hone and utilize parametric capacities as a powerful computational vector that augments the multi-layered, data-driven, and collaborative urban design process, producing generative urban configurations of greater ecological and infrastructural resilience.

Module- 1

Introduction to advanced analytical diagramming, urban big data scraping, and information graphics post-mapping for local and macro-scale urban systems. Integrating Geographic Information Systems (GIS) and open-source data streams (OSM) into computational models. Multi-layered mapping and representation of complex urban forces: stakeholder networks, demographic shifts, microclimate trends (such as Urban Heat Island intensities), socio-economic vectors, and multimodal transit infrastructure profiles.

Teaching-Learning Process	***ICT and Digital support**: Lecture will be conducted , through the use of powerpoint presentation*

Module-2

Translating qualitative and quantitative urban inferences into explicit parametric variables, boundary constraints, and generative opportunities. Operationalizing spatial logic to generate varied urban block, parcel, and building envelope configurations.

Teaching-Learning Process	***ICT and Digital support**: Lecture will be conducted , through the use of powerpoint presentation* ***Collaborative and Cooperative learning**: Analyze digitized urban metrics and consider computational input parameters across distinct spatial variations. Studying optimized structural forms to facilitate the generation of varied morphological iterations for resilient neighborhood typologies.*

Module-3

Development of a generative design agenda and a responsive urban concept addressing macro-scale metabolic issues, followed by specific computational site strategies addressing micro-scale opportunities. Deploying parametric platforms as vector fields for complex site formulation, land-use distribution, and street network synthesis. Mastery of specialized urban plugins and spatial syntax suites: Elk, DeCodingSpaces, Urbano, PedSim, and Space Syntax toolsets.

Teaching-Learning Process	***ICT and Digital support**: Lecture will be conducted , through the use of powerpoint presentation*

Module-4

Urban design evolution, systemic refinement, and automated multi-objective optimization within parametric platforms. Using evolutionary algorithms (e.g., Wallacei, Galapagos) to balance conflicting performance metrics like solar access, views, floor area ratio (FAR) maximization, walkability indices, and infrastructure cost reduction. Advanced 3D volumetric modeling, multi-scalar 2D digital drafting, digital twin visualization environments, and high-performance post-production representation workflows.

	Module-5	
	Studio synthesis and deployment: Students will map, configure, and execute all parametric analysis, algorithmic scripting sequences, and computational evaluation toolsets onto a designated site. Students will establish clear spatial analysis, draw algorithmic inferences, isolate systemic urban/environmental bottlenecks, and deliver an optimized, highly resilient generative urban master plan with integrated smart city framework dynamics.	
	Teaching-Learning Process	***ICT and Digital support**: Lecture will be conducted , through the use of powerpoint presentation*

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

CIE marks shall be awarded by a committee comprising of Principal/Dean, PG Course Coordinator/HOD and Guide/Co-guide of the department. The CIE marks awarded for PSC (professional supportive course), shall be based on the progress of the student throughout the semester, presentation skills in seminars and submission of the report

Semester End Examination:

- The student needs to submit his/her report done throughout the semester, including the data collection for the Viva examination, at least one day prior to the Viva examination to the PG course coordinator/HOD.
- The Viva-voce will be evaluated by external examiners appointed by the University along with PG Course coordinator/ guide/ co-guide or an internal examiner.
- The viva-voce marks list generated is to be signed by both internal and external examiners and submitted to VTU in the sealed cover through the Principal of the institution.

Suggested Learning Resources:
Books

- Jacobs, Jane (1961), The Death and Life of Great American Cities, Random House
- Maas, Winy (2013), MVRDV: Agenda for Urbanism, 010 Publishers
- Schumacher, Patrick (2011), Total Fluidity, University of Applied Arts Vienna

Web links and Video Lectures (e-Resources):

- https://www.researchgate.net/publication/255670004_Parametric_Design_in_Urban_Design
- https://www.sciencedirect.com/science/article/pii/S209526351830044X
- **https://otp.uni-weimar.de/courses/parametric-urban-design-analysis-puda-19-2/**

Skill Development Activities Suggested

Advanced mastery of Rhino/Grasshopper workflows paired with specialized urban and environmental analysis tools. Students will capture live spatial data, construct parametric urban subdivision systems, simulate pedestrian/vehicle mobility dynamics, track microclimatic impacts, and map optimized spatial solutions to establish automated city-planning blueprints.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Analyze urban areas of intervention and compute multi-criteria optimization pipelines for complex, multi-disciplinary city systems.	L2
CO2	Develop and codify a prescriptive approach to multi-disciplinary urban modeling and quantitative assessment of new or existing regional infrastructures.	L2
CO3	Rationalize and quantify an urban systems architecture problem by choosing appropriate fitness functions, spatial parameters, and zoning constraints.	L2
CO4	Subdivide a complex urban system into smaller relational parameters, manage computational data interfaces, and reintegrate them into a holistic master plan.	L3
CO5	Analyze and evaluate urban patterns to understand spatial evolution, agent behaviors, and multi-objective "survival of the fittest" morphological results.	L3

Program Outcome of this program. (CPM)

Sl. No.	Description	POs
1	Perform a critical evaluation and interpretation of generative urban optimization outputs, including sensitivity analysis and performance-versus-cost trade-offs.	PO1
2	Increase the student's operational knowledge in parametric urbanism, spatial computing, and automated design skillsets inside the field of architecture in general.	PO2
3	Transition from disparate baselines of data literacy to advanced, unified proficiencies in generative urban design and computational smart city analytics.	PO3
4	Demonstrate a verifiable increase in specialized computational layout routing, geographic simulation skills, and systemic design resolution.	PO4
5	Master the core mathematical and spatial concepts of multi-objective evolutionary optimization, including geometric Pareto optimality and fitness criteria.	PO5

Mapping of COS and POS

	PO1	PO2	PO3	PO4	PO5
CO1	L	M	M	H	H
CO2	L	M	H	M	L
CO3	0	M	M	H	H
CO4	0	M	M	L	H
CO5	L	L	M	M	H

H – High , M –Medium, L - Low

Semester- III

	DESIGN THESIS PHASE I : RESEARCH AND COMPUTATIONAL FRAMEWORK			
	Course Code	2MDAC302	CIE Marks	50
	Teaching Hours per semester (L:T:S)	14:14:28	Viva Marks	50
	Total Hours of Pedagogy	90 Hours	Total Marks	100
	Credits	3	Exam Hours	-

Course Learning objectives:

- To provide students with the opportunity to formulate an independent, original, and computationally driven research inquiry into a specialized architectural problem of their choice.
- To cultivate scientific proficiency in developing generative and parametric frameworks that align rigorous academic research with advanced design computation.
- To train students to synthesize cutting-edge literature, articulate explicit algorithmic logics, and establish a robust theoretical and computational methodology prior to physical or digital execution.

COURSE CONTENT

Research Content:

The thesis is an individual research project that constitutes a major piece of work undertaken by the student. It establishes the theoretical, algorithmic, and systemic foundation for the final design thesis. Students are expected to select a research inquiry focused on a live computational problem in the architectural discipline or a macro-issue having a direct bearing on the performance, optimization, and ecology of the built environment.

The topic must be highly researchable, shifting away from purely speculative forms to involve the scientific design of a computational study, rigorous data collection, parametric script formulation and environmental/spatial simulation. The aim is to prepare a state-of-the-art research report on the chosen digital paradigm and develop explicit parametric hypotheses or algorithmic logic pipelines to be systematically tested through the research methodology designed for the purpose.

The thesis proposal must include an overview of the proposed computational plan of work, including:

- **What to study:** The general scope of your digital inquiry, parameter definitions, and core research questions.
- **How to study this topic:** The technical methodology, software interoperability pipelines, genetic algorithm configurations, and optimization engines.
- **Why this topic needs to be studied:** The environmental, structural, or spatial significance of your study and its contribution to contemporary architectural discourse.

Thesis proposals are designed to:

- Justify and map out the algorithmic logic, data structures, and parametric rules of the research project.
- Show how your computational model or generative framework contributes to existing peer-reviewed international architectural research.
- Demonstrate to your advisor and review committee that you understand how to execute discipline-specific digital research, script testing, and simulation workflows within an acceptable academic timeframe.
- Recommend future optimization paths and computational study areas for further architectural exploration.

Research Process: Students are required to test their generative outcome proposals through empirical, algorithmic, and computational methods. This includes multi-objective optimization experiments, code/script auditing, performance simulation comparative matrices, and verified case-study benchmarks. Students must generate an innovative, data-driven insight on their specific spatial or structural issue.

Thesis work includes an iterative, highly technical research pipeline consisting of:

1. **Research Area Identification:** Isolating a gap in contemporary digital architecture fields.
2. **Computational Hypothesis:** Defining the relationship between design parameters (inputs) and performance targets (fitness functions).
3. **Literature Sourcing and Parsing:** Comprehensive search of international journals, digital library repositories, and computational precedents.
4. **Aim and Objective Definition:** Setting precise criteria for spatial, material, or environmental optimization.
5. **Formulation of Methodology:** Designing the algorithmic script architecture, data-flow diagrams, and simulation pipelines.
6. **Field and Dataset Planning:** Sourcing geographic information systems (GIS) data, weather data (.EPW), or material property matrices.
7. **Simulation and Data Collection:** Running iterative solver generations, recording performance metrics, and compiling algorithmic variants.
8. **Empirical Compilation and Inference Drawing:** Analyzing the behavioral trends of the parametric model under varying conditions.
9. **Research Validation:** Testing the validity of the generative model through deep case-study comparisons, physical/digital prototypes, and industry-standard simulation engine outputs.
10. **Discussion and Conclusion:** Critical synthesis of the research findings, limitations of the current script logic, and the formulation of systemic design recommendations for Phase II execution.

The progress of the Thesis work is presented, defended, and critiqued by the student periodically in a collaborative studio and review environment to monitor progress continuously. This rigorous feedback loop develops the analytical comprehension, computational reasoning, and advanced technical presentation skills of the students, guided by faculty to channelize their generative logic.

Area of Research: The subject for this specialized study must explicitly intersect advanced architectural theory with a computational execution framework. Research inquiries can be conceptual or applied but must pertain to the field of Digital Architecture, targeting specialized areas such as:

- **Generative and Parametric Morphologies:** Algorithmic form-finding, complex geometry rationalization, biomimetic design, fractal geometry and topological optimization.
- **Performance-Driven Simulation and Optimization:** Evolutionary multi-objective optimization (MOO), genetic algorithms, daylighting performance optimization, thermal behavior modeling, and microclimatic/aerodynamic form-finding.
- **Computational Urbanism and Spatial Data Science:** Space syntax, predictive agent-based pedestrian modeling, geographic information systems (GIS) spatial analysis, and algorithmic master-planning optimization.
- **Material Computation and Digital Fabrication:** Digital craft, robotic fabrication constraints, toolpath optimization scripting, material-informed generative design, and smart assembly matrices.
- **Responsive Environments and Smart Systems:** Kinematic facades, kinetic architecture, building management system (BMS) data integrations, interactive spatial responsive frameworks, and machine learning/AI-driven architectural design loops.

Presentation: The Thesis Project Phase I shall be formally submitted in the form of an academic research report and a digital presentation portfolio containing:

- Comprehensive parametric script architecture, data-flow diagrams, and algorithmic logic charts.
- High-resolution data visualizations, analytical graphs, and performance optimization matrices.
- Generative 3D digital models, geometric variations, and schematic computational drawings.
- Verified reference codes, international standards, site-specific environmental data reports, and analytical photographs of physical or digital prototypes.

Teaching-Learning Process	*Critical review with constructive suggestions / feed backs has to be provided by the Guide/ co-guide during the progress of the dissertation*

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

CIE marks shall be awarded by a committee comprising of Principal/Dean, PG Course Coordinator/HOD and Guide/Co-guide of the department. The CIE marks awarded for Design Thesis Phase – 1, shall be based on the progress of the student throughout the semester, presentation skills in seminars and submission of the report.

Semester End Examination

- The student needs to submit his/her report done throughout the semester, including the data collection for the Viva examination, at least one day prior to the Viva examination to the PG course coordinator/HOD.
- The Viva-voce will be evaluated by external examiners appointed by the University along with PG Course coordinator/ guide/ co-guide or an internal examiner.
- The viva-voce marks list generated is to be signed by both internal and external examiners and submitted to VTU in the sealed cover through the Principal of the institution.

Suggested Learning Resources:

Books

- Creswell, J. W; Research Design: Qualitative, quantitative and mixed methods approaches, 2nd Ed., Thousand Oaks: Sage. 2003.
- Kothari, C.R; Research Methodology: Methods and Techniques, New Delhi: WishwaPrakashan. 2005
- Sanoff, H; Visual research methods in design, USA: Van Nostrand Reinhold. 1991
  Caetano, I., Santos, L., S Leitão, A. (2020). *Computational design in architecture: Defining parametric, generative, and algorithmic design*. Frontiers of Architectural Research.
  Oxman, R., S Oxman, R. (Eds.). (2014). *Theories of the Digital in Architecture*. Routledge.

Web links and Video Lectures (e-Resources):

- Thesis Format | Dissertation Format | Paper, Structure, Sample | Leverage Edu
- ACADIA (Association for Computer Aided Design in Architecture) Research Repository
- eCAADe Open Access Digital Library

Skill Development Activities Suggested

- Advanced algorithmic design and multi-objective optimization masterclasses.
- Critical peer reviews of international journal papers (e.g., *International Journal of Architectural Computing*).
- Technical workshops featuring industry experts specializing in environmental simulation pipelines and digital fabrication.
- Field data tracking, spatial mapping exercises, and comparative digital case-study audits.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Synthesize an extensive literature matrix and harvest contextual datasets to formulate a clear, uncompromised design research question.	L3
CO2	Formulate a computational research hypothesis and map its parameters into an explicit, independent, and reproducible algorithmic framework.	L3
CO3	Design and experiment with performance-driven simulation workflows, testing geometric variants against rigorous predictive criteria.	L4
CO4	Evaluate preliminary data outputs to validate the computational model and project future optimization steps for Phase II execution.	L5

Program Outcome of this program. (CPM)

Sl. No.	Description	POs
1	Acquire advanced theoretical and practical knowledge in design computation, algorithmic logic, and digital architectural frameworks.	PO1
2	Encompass the ability to collaborate across transdisciplinary fields such as computer science, environmental engineering, and material science.	PO2
3	Demonstrate high-level problem-solving mastery through advanced data visualizations, parametric logic charting, and precision digital modeling.	PO3
4	Acquire expert software proficiency in generative systems, evolutionary solvers, and environmental/structural performance engines.	PO4
5	Synthesize complex systemic values to discover innovative, sustainable, and ecologically optimized architectural variations.	PO5
6	Integrate explicit contextual, environmental, spatial, and material parameters into holistic algorithmic design proposals.	PO6
7	Demonstrate the capacity to conduct autonomous, advanced research in emerging paradigms of digital and computational design.	PO7
8	Appraise professional standards, intellectual property integrity in open-source scripts, and ethical research responsibilities.	PO8

Mapping of COS and POS

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	H	M	H	M	H	H	H	H
CO2	H	M	H	H	M	M	H	H
CO3	M	H	H	H	H	H	H	M
CO4	M	H	H	H	H	H	H	H

H – High , M –Medium, L – Low

Semester- III

PROFESSIONAL ELECTIVE - III				
Course Code	2MDAC303x	CIE Marks	100
Teaching Hours per semester (L:T:P)	42:00:00	Term work	-
Total Hours of Pedagogy	90 Hours	Total Marks	100
Credits	3	Exam Hours	-

Course Learning objectives:

The objective of this elective course is to allow the students to cover a varied spectrum of domains of investigation within the premise of digital architecture. This course seeks to posit the role of different experimental threads within the broader context of digital practice. Specifically, it introduces physical computing networks, embedded microcontroller logic, sensor-actuator arrays, and adaptive spatial kinetics to merge data-driven software loops with responsive, real-world architectural environments.

2MDAC303A - CYBER-PHYSICAL SYSTEMS AND RESPONSIVE ENVIRONMENTS

Module-1: Foundations of Physical Computing and Cyber-Physical Networks

- **The Cyber-Physical Spatial Paradigm:** Defining cyber-physical systems (CPS) in architecture. Tracing the transition from static building components to responsive micro-environments and interactive envelopes.
- **Microcontroller Architectures and Signals:** Introduction to open-source hardware platforms (e.g., Arduino, Raspberry Pi, ESP32). Mastering analog vs. digital signals, pulse-width modulation (PWM), and serial communication interfaces.
- **The Architecture of Sensing:** Categorizing inputs for spatial tracking: environmental sensors (temperature, humidity, CO_2 levels), spatial occupancy sensors (PIR, ultrasonic, LiDAR, depth cameras), and user interaction metrics.
- **Data Processing and Signal Conditioning:** Managing sensor noise, calibrating thresholds, data smoothing, and setting up communication protocols (I2C, SPI, UART) to send sensor data into spatial models.

Teaching-Learning Process	***ICT and Digital support**: Lecture will be conducted , through the use of powerpoint presentation*

Module-2: Actuation Mechanics and Kinetic Tectonic Systems

- **The Kinetics of Actuation:** Translating digital commands into real-world physical motion. Mechanical principles of rotational, linear, and pneumatic actuation.
- **Motor Typologies and Control Circuits:** Selecting and wiring actuators: servo motors for precision angles, stepper motors for targeted positional rotation, and DC motors with relays for high-load actions.
- **Linkage Mechanics and Kinetic Envelopes:** Designing physical mechanisms—such as scissor joints, pantographs, origami folding structures, and tensegrity networks—to scale up localized motor movements into large spatial alterations.
- **Power Dynamics and Structural Safety:** Computing electrical current draws, specifying external power supplies, managing physical payload limits, and building automated mechanical stop safety loops.

Teaching-Learning Process	***ICT and Digital support**: Lecture will be conducted , through the use of powerpoint presentation*

	Module-3: Bidirectional IoT Networks and Smart Building Infrastructure
	• **Internet of Things (IoT) Architectures:** Building multi-node hardware communication layouts across spatial interiors and building facades. • **Wireless Protocols and Data Routing:** Deploying lightweight communication pathways (Wi-Fi, Bluetooth Low Energy (BLE), MQTT, HTTP REST APIs) to route multi-point sensor packets to central processing dashboards. • **Cloud Database Frameworks for Space:** Implementing time-series databases (e.g., InfluxDB, Firebase) to log historic spatial performance, occupancy profiles, and environmental fluctuations. • **Spatial Tracking Interfaces:** Creating custom graphical interfaces (dashboards) to view live spatial data, track equipment statuses, and override automated building tasks manually.
	Teaching-Learning Process — ***ICT and Digital support****: Lecture will be conducted , through the use of powerpoint presentation*
	Module-4: Behavioral Algorithms and Interactive Feedback Solvers
	• **Algorithmic State Machine Logic:** Designing rule-based reactive behaviors. Scripting conditional logic (if-then-else structures), state machine patterns, and temporal delay controls. • **Proportional-Integral-Derivative (PID) Control Loops:** Implementing closed-loop control mathematics to establish smooth, adaptive mechanical adjustments that eliminate erratic system oscillations. • **Computer Vision and Spatial Analytics:** Utilizing camera feeds to trace real-time human movement paths, density clouds, and facial expressions as immediate generative design inputs. • **Interactive Geometry Solvers:** Setting up data connections between hardware streams and algorithmic design tools to manipulate 3D computer models instantly based on user or environmental inputs.
	Teaching-Learning Process — ***ICT and Digital support****: Lecture will be conducted , through the use of powerpoint presentation*
	Module-5: Digital Twins, Cognitive Environments and Adaptive Envelopes
	• **The Living Digital Twin Interface:** Synchronizing a physical space with its virtual performance counterpart through constant, low-latency sensory data streams. • **Introduction to Machine Learning at the Edge:** Deploying lightweight predictive models (EdgeAI) directly onto microcontrollers to anticipate thermal, lighting, or user behavior needs. • **Ecosystemic Spatial Response:** Scaling interactive networks to coordinate climate-responsive shading skins, variable ventilation vents, and dynamic public lighting grids. • **Human-Building Ethics and Machine Lifecycle:** Evaluating data privacy in smart spaces, the lifecycle impacts of e-waste in architecture, and the evolving role of the occupant within automated spaces.
	Teaching-Learning Process — ***ICT and Digital support****: Lecture will be conducted , through the use of powerpoint presentation*

Semester- III

2MDAC303B - PARAMETRIC LANDSCAPE URBANISM AND TERRAMECHANICS	
Module-1: Foundations of Landscape Urbanism and Territorial Datasets	
• **The Landscape Urbanism Paradigm:** Tracing the shift from urbanism as a collection of static architectural objects to urbanism as an infrastructure of dynamic, living systems. Exploring the integration of ecological processes with parametric design. • **Geographical Information Systems (GIS) Integration:** Working with macro-scale territorial datasets. Sourcing and parsing Digital Elevation Models (DEM), contours, soil taxonomy layers, and regional hydrological networks. • **Point Cloud and LiDAR Data Processing:** Importing and converting unstructured 3D laser-scanned terrain data into flexible, edit-ready parametric NURBS surfaces and mesh fields. • **Territorial Scale Interoperability:** Setting up automated pipeline data loops between external GIS software and computational design platforms (e.g., Rhino/Grasshopper, QGIS) to construct responsive site models.	
Teaching-Learning Process	***ICT and Digital support**: Lecture will be conducted , through the use of powerpoint presentation*
Module-2: Computational Hydrology and Terrain Engineering	
• **Algorithmic Surface Runoff Analysis:** Simulating water flow pathways across complex terrains. Scripting watershed boundaries, stream order hierarchies, and localized flow accumulation vectors using rain gauge models. • **Slope Catchment and Soil Erosion Controls:** Identifying high-risk erosion locations by analyzing slope gradients, surface curvature maps, and velocity vectors. • **Parametric Landform Sculpting:** Designing grading plans, earthwork channels, bio-swales, and retaining retention basins that adapt smoothly to preexisting geological contours. • **Earthwork Volumetric Balancing:** Automating cut-and-fill volumetric calculations through parametric solvers to minimize soil removal and transportation costs from construction sites.	
Teaching-Learning Process	***ICT and Digital support**: Interactive software workflows using terrain analysis toolsets (e.g., Bison, Elk, or Land Kit plugins for Grasshopper) to display real-time drainage vectors and earthwork balancing parameters.*
Module-3: Terramechanics and Vehicle-Terrain Interactions	
• **Introduction to Terramechanics:** Understanding the physics of vehicle-terrain systems. Evaluating soft soil mechanics, vehicle locomotion, and the structural behavior of soils under operational machinery loads. • **Soil Shear Strength and Compaction Mechanics:** Analyzing soil shear stresses, sinkage parameters, and deformation thresholds using historical Bekker-Wong engineering models.	

	• **Machine Locomotion and Tracked Mobility:** Evaluating how heavy site-grading equipment, robotic excavators, and agricultural tracks deform or alter topsoil layouts. • **Predictive Rutting and Site Disruption Layouts:** Scripting algorithmic simulation overlays to predict ground rutting depths, compaction damage zones, and accessibility grids for heavy equipment during site deployment.
Teaching-Learning Process	***ICT and Digital support**: Lecture will be conducted , through the use of powerpoint presentation*
	Module-4: Parametric Eco-Vegetation Maps and Soil Metabolisms
	• **Algorithmic Vegetation Distributions:** Scripting multi-variable planting arrays driven entirely by environmental vectors: soil moisture maps, slope aspects, sun exposure matrices, and water accumulation zones. • **Computational Phytoremediation Networks:** Designing custom planting layouts optimized to absorb urban storm-water runoff and remove heavy metal toxins from degraded industrial soils. • **Parametric Micro-Climate Grids:** Simulating the impact of variable vegetation layouts on local wind velocities, air temperatures, and relative humidity across public parks. • **Soil-Water Dynamic Retentions:** Computational modeling of topsoil moisture shifts, ground evaporation rates, and subterranean water recharge profiles across changing annual timelines.
Teaching-Learning Process	***ICT and Digital support**: Live software demonstrations combining micro-climate tracking modules (e.g., Ladybug, Honeybee, or custom agent-based distribution frameworks) with biological planting matrices.*
	Module-5: Multi-Objective Landscape Optimization and Generative Infrastructure
	• **Evolutionary Landscape Optimization:** Setting up genetic algorithm workflows (e.g., Wallacei, Octopus) to resolve conflicting landscape criteria (e.g., maximizing storm-water storage while minimizing earth excavation and maximizing usable pedestrian fields). • **Generative Structural Subgrade Formulations:** Using topology optimization rules to generate non-standard urban retaining walls, custom river revetments, and reinforced soil embankments. • **The Living Landscape Digital Twin:** Conceptualizing live, bidirectional digital dashboards that link real-world site sensory streams (soil moisture gauges, water table trackers) with virtual territorial management configurations. • **Technical Constraints and Future Adaptation:** Evaluating international environmental codes, flood-plain safety rules, sea-level rise models, and long-term carbon-capture capacities in landscape architecture.
Teaching-Learning Process	***ICT and Digital support**: Lecture will be conducted , through the use of powerpoint presentation*

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

CIE marks shall be awarded by a committee comprising of Principal/Dean, PG Course Coordinator/HOD and Guide/Co-guide of the department. The CIE marks awarded for PSC (professional supportive course), shall be based on the progress of the student throughout the semester, presentation skills in seminars and submission of the report

Viva- Voce Examination:

- The student needs to submit his/her report done throughout the semester, including the data collection for the Viva examination, at least one day prior to the Viva examination to the PG course coordinator/HOD.
- The Viva-voce will be evaluated by external examiners appointed by the University along with PG Course coordinator/ guide/ co-guide or an internal examiner..
- The viva-voce marks list generated is to be signed by both internal and external examiners and submitted to VTU in the sealed cover through the Principal of the institution.

Suggested Learning Resources:

Core Reference Books

- Mostafavi, M., S Doherty, G. (Eds.). (2010). *Ecological Urbanism*. Lars Müller Publishers.
- Waldheim, C. (2016). *Landscape as Urbanism: A General Theory*. Princeton University Press.
- Wong, J. Y. (2008). *Theory of Ground Vehicles* (4th ed.). John Wiley S Sons. *(Key text for Terramechanics).*
- Reed, C., S Lister, N. M. (Eds.). (2014). *Projective Ecologies*. Actar.
- Corner, J. (1999). *Recovering Landscape: Essays in Contemporary Landscape Architecture*. Princeton Architectural Press.
- Bekker, M. G. (1969). *Introduction to Terrain-Vehicle Systems*. University of Michigan Press.

Web links and Video Lectures (e-Resources):

- Landscape Urbanism Open Research Network and Core Theory Hub
- International Society for Terrain-Vehicle Systems (ISTVS Platform)
- QGIS Open Source Geographic Information System Network

Skill Development Activities Suggested -

- **Automated Terrain Catchment Setup:** Authoring an error-free script in Grasshopper to trace rain accumulation pathways across a heavily contoured site mesh, establishing automated locations for water retaining ponds.
- **Vehicle Compaction Mapping:** Configuring an automated path-tracking layout in a simulation engine that maps wheel loads and predicts soil sinkage profiles across varying clay, sand, and topsoil mixes.
- **Studio-1 Project Landscape Integration:** Utilizing the student's concurrent primary Design Studio-1 project to select a major site network or waterfront zone and execute a complete parametric grading plan, watershed analysis, and eco-vegetation mapping loop.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	To characterize central concepts of GIS mapping, runoff vectors, soil shear equations, and terramechanical dynamics.	L2
CO2	Enable students to understand engineering limitations and data errors when moving from standard decoration zoning to performative landscape urbanism.	L2
CO3	To develop skills in qualitative and quantitative earthwork calculations, soil sinkage tracking, and watershed simulation maps.	L3
CO4	To develop advanced understanding of multi-objective evolutionary solvers, ecosystem distribution rules, and mesh grading parameters.	L3
CO5	To critically interpret and apply parametric terramechanical and landscape workflows toward resolved site masterplans, earthwork installations, and regional infrastructure strategies.	L4

Program Outcome of this program. (CPM)

Sl. No.	Description	POs
1	**Theoretical Relevance:** Understand the core historical and contemporary relevance of landscape urbanism frameworks, terramechanical structures, and ecological parameters within regional design theory.	PO1
2	**Workflow Limitations:** Gauge and document the technical boundaries, system simplifications, and mathematical limits when moving heavy machine routing and soil systems through digital evaluation engines.	PO2
3	**Data Synthesis:** Understand and master qualitative and quantitative GIS data indexing, annual hydrological runoff tracking, and soil shear load data logs.	PO3
4	**Computational Application:** Develop a deep understanding of automated multi-variable optimization layouts, parametric grading configurations, and multi-agent planting distribution models.	PO4
5	**Critical Structural Interpretation:** Critically interpret, evaluate, and integrate computational terrain simulation outputs with real-world site remediation, machine logistics, and durable project construction delivery.	PO5

Mapping of COS and POS

	PO1	PO2	PO3	PO4	PO5
CO1	**H**	**M**	**L**	**M**	**H**
CO2	**L**	**H**	**M**	**M**	**H**
CO3	**L**	**M**	**M**	**M**	**H**
CO4	**M**	**L**	**M**	**M**	**M**
CO5	**L**	**L**	**M**	**M**	**H**

H – High , M –Medium, L – Low

Semester- III

2MDAC303C - ALGORITHMIC DESIGN AND COMPLEX SYSTEMS	
Module-1: Algorithmic Logic, Visual Programming and Explicit Computations	
• **The Transition to Algorithmic Thinking:** Moving from computer-aided drafting and explicit 3D modeling to procedural logic and rule-based design. Understanding parameters, constraints, and dependencies. • **Mathematical Structures in Architecture:** Scripting with vector math, plane transformations, matrix coordinate transformations, trigonometric fields, and non-uniform rational B-splines (NURBS) topology. • **Data Trees and Logic Structuring:** Mastering advanced data management architectures: nesting, grafting, flattening, shifting, and path mapping within visual programming environments. • **Text-Based Scripting Integration:** Introduction to extending visual scripts through text-based syntax (e.g., Python, C#), authoring custom conditional loops, definitions, and geometric routines.	
Teaching-Learning Process	***ICT and Digital support**: Lecture will be conducted , through the use of powerpoint presentation*
Module-2: Self-Organization, Fractals and Recursive Morphogenesis	
• **Principles of Complex Systems:** Understanding feedback loops, non-linearity, emergence, and self-organization within natural and synthetic structures. • **Recursive Systems and L-Systems:** Authoring deterministic and stochastic Lindenmayer Systems (L-systems) to generate fractal branching networks, structural space frames, and urban grids. • **Cellular Automata Formulations:** Deploying 1D, 2D, and 3D discrete state-automata arrays (e.g., Conway's Game of Life, voxel automata) to simulate emergent spatial configurations and material distributions. • **Reaction-Diffusion Patterns:** Implementing Turing morphogenetic equations to generate differentiated surface textures, structural stiffening ribs, and acoustic tiling.	
Teaching-Learning Process	***ICT and Digital support**: Lecture will be conducted , through the use of powerpoint presentation*
Module-3: Agent-Based Modeling (ABM) and Swarm Intelligence	
• **Swarm Behavior Fundamentals:** Abstracing bottom-up emergent logic from social organisms (flocking birds, schooling fish, foraging ants). Defining cohesion, alignment, and separation rules. • **Multi-Agent Simulation Frameworks:** Setting up autonomous digital agents embedded with localized behavioral traits to generate complex path systems, vector fields, and spatial webs. • **Stigmergy and Environment Feedback:** Coding behavioral paths where simulated agents alter and respond directly to localized digital conditions (e.g., material deposition, trace paths). • **Behavioral Architectural Assemblies:** Translating agent trace networks into explicit tectonic materializations, wireframe structures, and variable-density panel layouts.	

	Teaching-Learning Process	***ICT and Digital support**: Live software demonstrations using multi-agent simulation engines (e.g., Grasshopper plugins like Quelea, Culebra, or custom Python scripts) to show real-time path emergence and system dynamics.*
	Module-4: Structural and Component Discretization, Voxelization and Aggregation	
	• **Discrete Computational Architecture:** Shifting from continuous, continuous-surface topology to discrete, modular, and combinatorial spatial systems. • **Voxelization and Spatial Packing:** Discretizing complex volumetric bounding wrappers into uniform or differentiated 3D pixel grids (voxels) for optimized programming. • **Combinatorial Aggregation Logic:** Scripting rule-based assembly algorithms (Wave Function Collapse, serial aggregation) to pack non-standard discrete building components. • **Tectonic Rationalization Protocols:** Converting double-curved complex surfaces into flat, developable planar quadrilateral facets, optimized for assembly joints.	
	Teaching-Learning Process	***ICT and Digital support**: Lecture will be conducted , through the use of powerpoint presentation*
	Module-5: Multi-Objective Evolutionary Optimization and Machine Learning Foundations	
	• **Evolutionary Computing Frameworks:** Mirroring natural selection trajectories by establishing multi-variable design files. Defining variables (genes), permutations (chromosomes), and goals (fitness fields). • **Navigating the Pareto Frontier:** Operating genetic solvers to handle conflicting targets (e.g., structural mass reduction vs. daylight maximization). Sorting and tracking multi-generational data charts. • **Introduction to Neural Networks in Design:** Conceptualizing the application of machine learning architectures (e.g., Generative Adversarial Networks - GANs, Diffusion Models) for spatial pattern recognition and configuration generation. • **Complex System Dashboards:** Consolidating generative geometric variables, evolutionary performance data, and component metrics into a live computational digital twin interface.	
	Teaching-Learning Process	***ICT and Digital support**: Lecture will be conducted , through the use of powerpoint presentation*

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

CIE marks shall be awarded by a committee comprising of Principal/Dean, PG Course Coordinator/HOD and Guide/Co-guide of the department. The CIE marks awarded for PSC (professional supportive course), shall be based on the progress of the student throughout the semester, presentation skills in seminars and submission of the report

Viva- Voce Examination:

- The student needs to submit his/her report done throughout the semester, including the data collection for the Viva examination, at least one day prior to the Viva examination to the PG course
- coordinator/HOD. The Viva-voce will be evaluated by external examiners appointed by the University along with PG Course coordinator/ guide/ co-guide or an internal examiner..
- The viva-voce marks list generated is to be signed by both internal and external examiners and submitted to VTU in the sealed cover through the Principal of the institution.

Suggested Learning Resources:

Core Reference Books

- Terzidis, K. (2006). *Algorithmic Architecture*. Architectural Press.
- Hensel, M., Menges, A., S Weinstock, M. (2010). *Emergent Technologies and Design: Towards a Biological Paradigm for Architecture*. Routledge.
- Menges, A. (2011). *Computational Design Thinking*. John Wiley S Sons.
- Carpo, M. (2017). *The Second Digital Age: Beyond Architectural Indexicality*. MIT Press.
- Mitchell, M. (2009). *Complexity: A Guided Tour*. Oxford University Press.
- Leach, N., S Yuan, P. F. (Eds.). (2021). *Scripting the Future: Proceedings of the DigitalFUTURES International Conference*. Springer.

Web links and Video Lectures (e-Resources):

- DigitalFUTURES International Computational Design Platform
- Santa Fe Institute - Research in Complex Adaptive Systems
- Grasshopper Algorithmic Modeling Community Network

Skill Development Activities Suggested -

- Advanced Data Tree Scripting: Authoring an error-free computational script in Grasshopper that parses, path-maps, and sorts an array of intersecting geometric points into nested concentric spatial clusters without flattening datasets.
- Multi-Agent Trail Optimization: Configuring a multi-agent flocking code routine where individual agents interact with vector path obstacles, producing an optimized structural canopy network layout.
- Studio-1 Project System Integration: Utilizing the student's concurrent primary Design Studio-1 project to select a complex facade shell or public programmatic cluster and execute a complete combinatorial aggregation, voxelization, or recursive morphogenesis loop.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	To characterize central concepts of data trees, explicit scripting syntax, emergent swarms, recursive growth, and voxel grids.	L2
CO2	Enable students to understand architectural limitations and processing errors when shifting from linear top-down modeling to complex bottom-up systems.	L2
CO3	To develop skills in qualitative and quantitative code debugging, agent trajectory tracking, and surface rationalization mapping.	L3
CO4	To develop advanced understanding of multi-objective evolutionary solvers, Pareto frontier sorting, and machine learning structures.	L3
CO5	To critically interpret and apply algorithmic design and complex system workflows toward resolved component aggregation, material surfaces, and architectural systems.	L4

Program Outcome of this program. (CPM)

Sl. No.	Description	POs
1	**Theoretical Relevance:** Understand the core historical and contemporary relevance of algorithmic generation, complexity theory, and emergent structures inside contemporary digital practice.	PO1
2	**Workflow Limitations:** Gauge and document the technical boundaries, computing performance barriers, and system logic rules when tracking physical spatial layouts through complex code structures.	PO2
3	**Data Synthesis:** Understand and master qualitative and quantitative parameter variables, generative data tracking codes, and multi-generational fitness metric sets.	PO3
4	**Computational Application:** Develop a deep understanding of automated multi-agent interactions, recursive branching parameters, and combinatorial spatial algorithms.	PO4
5	**Critical Structural Interpretation:** Critically interpret, evaluate, and integrate computational system configurations with buildable component joints, physical material tolerances, and on-site assembly conditions.	PO5

Mapping of COS and POS

	PO1	PO2	PO3	PO4	PO5
CO1	**H**	**M**	**L**	**M**	**H**
CO2	**L**	**H**	**M**	**M**	**H**
CO3	**L**	**M**	**M**	**M**	**H**
CO4	**M**	**L**	**M**	**M**	**M**
CO5	**L**	**L**	**M**	**M**	**H**

H – High , M –Medium, L – Low

Semester- III

	DIGITAL ARCHITECTURE APPLICATION ON REAL-TIME PROJECTS			
	Course Code	2MDAC304	CIE Marks	50
	Teaching Hours per semester (L:T:P)	00:00:56	Viva Marks	50
	Total Hours of Pedagogy	210 Hours	Total Marks	100
	Credits	7	Exam Hours	-

Course Learning objectives:

The course aims to provide students with an opportunity to apply the knowledge, skills and digital workflows acquired through the Digital Architecture programme to **real-time architectural projects** in a professional/industry environment.

The course objectives are:

- **To apply** computational, parametric and digital design methods to real-time architectural projects.
- **To develop** proficiency in using appropriate digital tools for modelling, visualization, BIM, simulation, analysis and project documentation.
- **To integrate** digital design processes with architectural, structural, environmental and construction requirements of real projects.
- **To understand** professional project workflows, coordination procedures, standards, codes, regulations and documentation practices.
- **To develop** the ability to work collaboratively with architects, engineers, consultants, fabricators and other professionals in an interdisciplinary environment.
- **To evaluate** design alternatives using appropriate digital analysis, simulation and performance-based methods.
- **To translate** computational and digital design concepts into technically feasible and professionally communicable architectural solutions.
- **To develop** professional skills in project communication, presentations, meetings, reporting, time management and client/consultant interaction.
- **To develop** independent working skills, professional responsibility, problem-solving ability and readiness for digital architectural practice.

Real-Time Project:

Students, under the guidance of internal faculty and external/professional guides, shall participate in the development and execution of assigned real-time architectural projects, as applicable to the professional practice environment.

Students shall engage in appropriate stages of the project, including project understanding, site/project analysis, digital modelling, BIM coordination, computational/parametric workflows, visualization, analysis, documentation, presentations and coordination with relevant professionals, as applicable to the project.

Students shall maintain regular records of their work, progress and professional interactions and shall comply with the professional practices, confidentiality requirements, project standards and timelines of the host organization/project environment.

Course outcome

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

- Present the assigned real-time project and explain the project objectives, scope, methodology and digital workflow adopted.
- Demonstrate the application of digital architecture tools and techniques in the project.
- Present the project development, analysis, coordination, documentation and outcomes.
- Answer questions and participate in discussions related to the project.
- Submit a **duly documented and certified project report** endorsed by the internal guide and external/professional guide, wherever applicable.

Assessment Details (both CIE and SEE)

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Continuous Internal Evaluation:

CIE marks shall be awarded by a committee comprising of Principal/Dean, PG Course Coordinator/HOD and Guide/Co-guide of the department. The CIE marks shall be awarded based on the student's progress throughout the semester, participation in project activities, quality of project work, documentation, presentations, professional conduct and submission of the prescribed project report.

Semester End Examination:

- The student needs to submit his/her report done throughout the semester, including the data collection for the Viva examination, at least one day prior to the Viva examination to the PG course coordinator/HOD.
- The Viva-voce will be evaluated by external examiners appointed by the University along with PG Course coordinator/ guide/ co-guide or an internal examiner.
- The viva-voce marks list generated is to be signed by both internal and external examiners and submitted to VTU in the sealed cover through the Principal of the institution.

Skill Development Activities Suggested

- Identify areas for future knowledge and skill development in digital architectural practice.
- Develop professional judgement, critical thinking, problem-solving and decision-making abilities.
- Apply computational, parametric, BIM and digital design skills to real-time architectural projects.
- Develop proficiency in project documentation, visualization, digital modelling and interdisciplinary coordination.
- Strengthen professional communication, presentation, reporting, time management and teamwork skills.
- Develop awareness of applicable professional standards, codes, regulations and ethical practices.
- Reflect on project outcomes and identify opportunities for further improvement and professional development.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Demonstrate understanding of professional workflows, project processes, standards and responsibilities in digital architectural practice.	L2- Understand
CO2	Apply computational, parametric, BIM and digital representation methods to real-time architectural projects.	L3- Apply
CO3	Analyze project requirements and integrate appropriate digital tools for modelling, simulation, documentation and visualization.	L4- Analyze
CO4	Collaborate with architects, engineers, consultants and industry professionals in interdisciplinary project environments.	L3- Apply
CO5	Develop and present professional digital project documentation demonstrating technical, analytical and communication skills.	L6- Create

Program Outcome of this program. (CPM)

Sl. No.	Description	POs
1	Demonstrate advanced knowledge and understanding of digital architectural design, computational methods, technologies and processes.	PO1
2	Demonstrate the ability to work collaboratively and effectively with interdisciplinary teams, professionals, consultants and stakeholders.	PO2
3	Demonstrate creativity, critical thinking and problem-solving abilities through computational design, digital modelling, simulation and professional-quality architectural representation.	PO3
4	Demonstrate professional competence through the application of digital tools, research, technical knowledge, project management and emerging technologies in architectural practice.	PO4
5	Develop and implement innovative architectural solutions that integrate contextual, social, cultural, economic, ethical, environmental and technological considerations.	PO5

Mapping of COS and POS

	PO1	PO2	PO3	PO4	PO5
CO1	**H**	**M**	**L**	**H**	**M**
CO2	**H**	**M**	**H**	**H**	**M**
CO3	**H**	**M**	**H**	**H**	**H**
CO4	**M**	**H**	**M**	**H**	**M**
CO5	**H**	**H**	**H**	**H**	**H**

H – High , M – Medium, L – Low

— — — END OF SEMESTER — — —