

## Semester- II

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| PERFORMATIVE AND ECOLOGICAL DESIGN STUDIO                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  |                                                                                                                                                                                                                                                                             |             |     |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |  | 2MDAC201                                                                                                                                                                                                                                                                    | CIE Marks   | 50  |
| Teaching Hours per semester (L:T:S)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  | 14:14:98                                                                                                                                                                                                                                                                    | Viva Marks  | 50  |
| Total Hours of Pedagogy                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  | 270 Hours                                                                                                                                                                                                                                                                   | Total Marks | 100 |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  | 9                                                                                                                                                                                                                                                                           | Exam Hours  | -   |
| <b>Course Learning objectives (CLO):</b><br><br>This unit of study introduces explorative and creative thinking expressed through the application of digital software to performance-driven design propositions. Students will develop the ability to use digital software for the development, simulation, and execution of parametrically optimized, ecologically responsive building typologies.                                                                                                                                                      |  |                                                                                                                                                                                                                                                                             |             |     |
| Module-1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |                                                                                                                                                                                                                                                                             |             |     |
| Decoding the performative design process as a collaborative, iterative, and evolutionary vector framework. Introduction to ecological architecture metrics, systems thinking, and data-driven design. Collaborative-spatial design and parameters; iterative methods to understand ecological boundaries and form complex, performance-oriented systems. Analysis of international case studies of high-performance parametric architecture, evaluating their environmental impacts, carbon footprints, and computational workflows.                     |  |                                                                                                                                                                                                                                                                             |             |     |
| Teaching-Learning Process                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  | ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation                                                                                                                                                                             |             |     |
| Module-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |                                                                                                                                                                                                                                                                             |             |     |
| Role of environmental diagramming, microclimate analysis, and site-data mapping in translating ecological parameters to parametric platforms. Multi-criteria data mapping (solar radiation, wind vectors, microclimatic data) into relevant computational design inputs. Utilizing computational tools to produce creative design outcomes in a digital environment with reference to appropriate parametric software. Application of core ecological design principles including passive solar strategies, thermal zoning, and site-responsive massing. |  |                                                                                                                                                                                                                                                                             |             |     |
| Teaching-Learning Process                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  | Collaborative and Cooperative learning: physical case studies<br>ICT and Digital support: To introduce and understand different parameters and constraints to incorporate into the analysis and study of the project . power presentation for relevant studies and analysis |             |     |
| Module-3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |                                                                                                                                                                                                                                                                             |             |     |
| Identifying and defining the role of parametric and generative platforms as powerful design tools that augment performative exploration and execution. Introduction to generative design principles, evolutionary algorithms, and multi-objective optimization techniques. Simulating, testing, and optimizing building geometries against critical ecological metrics including daylight autonomy, glare control, and annual energy consumption.                                                                                                        |  |                                                                                                                                                                                                                                                                             |             |     |
| Teaching-Learning Process                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  | ICT and Digital support Lecture will be conducted through the use of powerpoint presentations; generative software tools and visual programming platforms (e.g., Grasshopper, Galapagos, Wallacei) will be taught.                                                          |             |     |
| Module-4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |                                                                                                                                                                                                                                                                             |             |     |
| Ecological material performance and whole-building life cycle assessment (WBLCA). Developing and documenting individual performative design concepts and outcomes framed by an ecological brief. Identifying and using appropriate simulation software (e.g., EnergyPlus, Ladybug Tools) to execute intended design outcomes, performing advanced daylighting analysis, thermal comfort modeling (PMV(Predicted Mean Vote)/PPD (Predicted Percentage of Dissatisfied)), and carbon accounting calculations.                                              |  |                                                                                                                                                                                                                                                                             |             |     |

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| <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <i><b>ICT and Digital support:</b> Lecture will be conducted , through the use of power point presentation ,software tools will be taught</i> |
| <b>Module-5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                               |
| Applying vector-oriented and adaptive design software to achieve multi-objective ecological objectives. Designing responsive architectural envelopes, kinetic skins, and climate-adaptive building systems. Producing creative, resilient design outcomes in a digital environment with reference to appropriate parametric software used for designing an ecologically synchronized building typology.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                               |
| <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <i><b>ICT and Digital support:</b> Lecture will be conducted , through the use of power point presentation</i>                                |
| <p><b>Assessment Details (both CIE and SEE)</b></p> <p>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.</p> <p><b>Continuous Internal Evaluation:</b></p> <p>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</p> <p><b>Semester End Examination:</b></p> <ul style="list-style-type: none"> <li>• 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.</li> <li>• 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.</li> </ul> |                                                                                                                                               |
| <p><b>Suggested Learning Resources:</b></p> <p><b>Books</b></p> <ul style="list-style-type: none"> <li>• Tschumi, Bernard ; Notations: Diagrams and Sequences</li> <li>• Koolhaas, Rem ; Delirious New York: A Retroactive Manifesto for Manhattan,</li> <li>• Fenton, Joseph , Pamphlet Architecture 11: Hybrid Buildings</li> <li>• Woodbury, Robert ; Elements of Parametric Design, Routledge New York</li> <li>• Oxman, Rivka and Robert ; Theories of the Digital in Architecture, Routledge New York.</li> <li>• Menges, Achim; <i>Material Computation: Higher Integration in Morphogenetic Design</i>, Wiley.</li> <li>• Hensel, Michael; <i>Performance-Oriented Architecture: Rethinking Architectural Design and the Built Environment</i>, Wiley.</li> <li>• Moe, Kiel; <i>Convergence: An Architectural Agenda for Energy</i>, Routledge.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                               |

**Web links and Video Lectures (e-Resources):**

- <https://www.danieldavis.com/a-history-of-parametric/>
- <https://vdoc.pub/download/scripting-cultures-architectural-design-and-programming-53g6jiss52r0>
- <https://davidfrico.com/evolutionary-architecture-principles.pdf>
- <https://www.perlego.com/book/2388244/from-control-to-design-pdf>
- <https://www.youtube.com/watch?v=SY2VUBE6SgA>
- <https://www.ladybug.tools/resource.html> (Environmental Simulation Resources)

**Skill Development Activities Suggested**

Students will work on above mentioned in detail and will submit the work in the form of drawings and/ models and supplementary documentation as found suitable to explain the design process and product judiciously

**Course outcome (Course Skill Set)**

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

| Sl. No. | Description                                                                                                                                         | Blooms Level |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| C01     | Synthesize complex ecological data and performative knowledge acquired throughout the year into cohesive architectural designs.                     | L2           |
| C02     | Understand and implement advanced developments in BIM, parametric simulation, generative design, and environmental modeling platforms.              | L2           |
| C03     | Advance their knowledge of contemporary ecological discourse and performative metrics in close relation to the design task.                         | L3           |
| C04     | Understand and execute the comprehensive design workflow of a high-performance, climate-responsive building project.                                | L4           |
| C05     | Establish new ways of thinking about regenerative architecture, environmental fabrication, professional practice, and its global ecological impact. | L4           |

**Program Outcome of this program. (CPM)**

| Sl. No. | Description                                                                                                                                                                               | POs |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 1       | Decoding the architectural design process as a collaborative, iterative, and evolutionary vector and performative framework.                                                              | PO1 |
| 2       | The course/project goal is to increase the student's knowledge in performative design and advanced computational skills in the field of architecture in general.                          | PO2 |
| 3       | The students will enter the project with varying degrees of ecological systems knowledge/skills and will subsequently end up at advanced technical levels at the end of the course.       | PO3 |
| 4       | The individual student must show an increase in the particular software simulation and analytical skills offered and in ecological architecture in general.                               | PO4 |
| 5       | A framework is proposed as a disciplinary bridge to enable the team members to collaboratively identify and employ appropriate processes to implement morphogenetic and performative IBs. | PO5 |

**Mapping of COS and POS**

|     | PO1 | PO2 | PO3 | PO4 | PO5 |
|-----|-----|-----|-----|-----|-----|
| C01 | 0   | M   | M   | H   | H   |
| C02 | L   | M   | H   | M   | L   |
| C03 | 0   | M   | M   | H   | H   |
| C04 | 0   | M   | M   | L   | H   |
| C05 | L   | L   | M   | M   | H   |

H - High, M - Medium, L - Low

## Semester- II

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| KINETIC ARCHITECTURE AND INTERACTIVE SYSTEMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |  |                                                                                                 |             |     |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |  | 2MDAC202                                                                                        | CIE Marks   | 50  |
| Teaching Hours per semester (L:T:S)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  | 28:00:28                                                                                        | Viva Marks  | 50  |
| Total Hours of Pedagogy                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |  | 120 Hours                                                                                       | Total Marks | 100 |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |  | 4                                                                                               | Exam Hours  | -   |
| <b>Course Learning objectives:</b><br>Gain insight into kinetic architecture’s core mechanisms, principles, and historical evolution. Explore the seamless integration of mechanical systems, smart materials, sensors, and microcontrollers. Develop advanced skills to design, simulate, prototype, and critique innovative, responsive physical systems that transform spatial environments and address urban and environmental changes.                                                                                                                                                                          |  |                                                                                                 |             |     |
| Module- 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  |                                                                                                 |             |     |
| Overview, definition, and historical evolution of kinetic architecture and mechanical building envelopes. Importance of transformable, deployable, and adaptive physical structures in contemporary design. Key Concepts: Principles of rigid-body kinematics, folding mechanisms (origami/tessellation), and structural mobility. Exploring the relationship between environmental stimuli, user behavior, and moving spatial systems. Case Studies: Analysis of global kinetic projects (e.g., adaptive facades, operable roofs), evaluating their mechanical systems, design intent, and operational reliability. |  |                                                                                                 |             |     |
| Teaching-Learning Process                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  | ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation |             |     |
| Module-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  |                                                                                                 |             |     |
| Introduction to the technical ecosystem of kinetic and interactive systems: sensors, microcontrollers, mechanical actuators, and responsive materials. Overview of building-scale automation networks and Internet of Things (IoT) frameworks for physical space control. Sensing Technologies: Deep dive into spatial sensing arrays (ultrasonic, LiDAR, PIR motion tracking, environmental sensors) and data acquisition strategies. Methods for clean integration of real-time sensor streams into dynamic building control logic.                                                                                |  |                                                                                                 |             |     |
| Teaching-Learning Process                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  | ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation |             |     |
| Module-3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  |                                                                                                 |             |     |
| Actuation mechanisms and force transmission systems for kinetic elements: pneumatic, hydraulic, motorized (servo/stepper), and smart material systems (Shape Memory Alloys, Electro-active Polymers). Designing closed-loop feedback systems for real-time, precision-controlled physical movement. Interactive Design Principles: User-centered UX approaches for adaptive spaces, focusing on safety, structural failure mitigation, and inclusivity. Hands-on physical computing: experimenting with basic microcontrollers, sensor nodes, and physical actuators to build operational kinetic scale models.      |  |                                                                                                 |             |     |
| Teaching-Learning Process                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  | ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation |             |     |

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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Digital interfaces, spatial computing, and physical-digital interaction protocols. Introduction to computer vision, computer-aided tracking, and spatial interfaces used to command physical kinetic structures. Gesture and Motion-Based Interaction: Designing intelligent architectural environments that parse human posture, gestures, and behavioral patterns to trigger kinetic deformation. Case studies focusing on human-building interaction (HBI) paradigms and gesture-controlled spatial systems.                                            |                                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <i>ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation</i> |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Module-5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Responsive environmental control systems: integrated kinetic shading, acoustic dampening arrays, dynamic lighting, and directional soundscapes. Kinetic structures at the civic scale: interactive urban pavilions, smart public space installations, and deployable urban interventions. The strategic role of kinetic architecture within smart city frameworks, resource distribution networks, and spatial computing fields. Prototyping, stress-testing, and validating hardware-in-the-loop kinetic concepts in a controlled laboratory environment. |                                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <i>ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation</i> |
| <b>Assessment Details (both CIE and SEE)</b><br><p>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.</p> <p><b>Continuous Internal Evaluation:</b><br/> 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</p> <p><b>Semester End Examination:</b></p> <ul style="list-style-type: none"> <li>• 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.</li> <li>• 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.</li> <li>• 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.</li> </ul> <p><b>Suggested Learning Resources:</b><br/> <b>Books</b></p> <ul style="list-style-type: none"> <li>• Fox, Michael; Interactive Architecture: Adaptive World, Princeton Architectural Press.</li> <li>• Schumacher, Michael; Architectural Kinetics: Building in Motion, Birkhäuser.</li> <li>• Bahga, Arshdeep and Madiseti, Vijay; Internet of Things: A Hands-on Approach, Universities Press, 2015.</li> <li>• Karvinen, Tero, Karvinen, Kimmo and Valtokari, Ville; Make: Sensors, 1st Edition, Maker Media, 2014.</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                        |

**Web links and Video Lectures (e-Resources):**

- [https://www.tutorialspoint.com/internet\\_of\\_things/internet\\_of\\_things\\_tutorial.pdf](https://www.tutorialspoint.com/internet_of_things/internet_of_things_tutorial.pdf)
- <https://www.youtube.com/watch?v=LlhmzVL5bm8>
- <https://www.youtube.com/watch?v=Fj02iTrWUx0>

**Skill Development Activities Suggested**

Students will be able to configure basic communication protocols in sensor-actuator networks. Program and wire microcontroller platforms (e.g., Arduino ecosystem) for automated physical components. Implement Python programming, serial interfacing, and data parsing routines on single-board computers (e.g., Raspberry Pi) to design and run comprehensive kinetic IoT architectural models.

**Course outcome (Course Skill Set)**

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

| Sl. No. | Description                                                                                                                   | Blooms Level |
|---------|-------------------------------------------------------------------------------------------------------------------------------|--------------|
| C01     | Synthesize technical knowledge of mechanical linkages, sensing structures, and microcontrollers acquired throughout the year. | L2           |
| C02     | Understand and program hardware communication protocols to exchange data efficiently across physical sensor networks.         | L3           |
| C03     | Advanced their knowledge on designing, wiring, and programming microcontroller boards for distinct mechanical movements.      | L3           |
| C04     | Deploy Python programming and serial communication strategies to link software intelligence with hardware actuators.          | L4           |
| C05     | Design, test, and troubleshoot comprehensive, multi-domain kinetic architecture and IoT system models.                        | L4           |

**Program Outcome of this program. (CPM)**

| Sl. No. | Description                                                                                                                                              | POs |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 1       | Interpret the impact, mechanical challenges, and systemic requirements posed by kinetic and IoT networks leading to new architectural models.            | PO1 |
| 2       | Compare and contrast the deployment of mechanical actuators, smart objects, and the fieldbus technologies used to network them.                          | PO2 |
| 3       | Appraise the role of serial and network communication protocols for low-latency, real-time physical feedback loops.                                      | PO3 |
| 4       | Elaborate the necessity for edge computing, physical safety protocols, and operational loop security within automated building spaces.                   | PO4 |
| 5       | Illustrate different actuator and sensor options to execute precise physical transformation and identify applications of industrial IoT in architecture. | PO5 |

**Mapping of COS and POS**

|     | PO1 | PO2 | PO3 | PO4 | PO5 |
|-----|-----|-----|-----|-----|-----|
| C01 | 0   | M   | M   | M   | H   |
| C02 | L   | M   | M   | M   | M   |
| C03 | 0   | L   | M   | M   | H   |
| C04 | L   | 0   | L   | L   | M   |
| C05 | 0   | L   | L   | M   | H   |

H - High, M - Medium, L - Low

## Semester- II

|  |                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                          |             |     |
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|  | DIGITAL ARCHITECTURE PROCESS THEORIES AND HISTORY -II                                                                                                                                                                                                          |                                                                                                                                                                                                                          |             |     |
|  | Course Code                                                                                                                                                                                                                                                    | 2MDAC203                                                                                                                                                                                                                 | CIE Marks   | 50  |
|  | Teaching Hours per semester (L:T:P)                                                                                                                                                                                                                            | 42:00:00                                                                                                                                                                                                                 | SEE Marks   | 50  |
|  | Total Hours of Pedagogy                                                                                                                                                                                                                                        | 90 Hours                                                                                                                                                                                                                 | Total Marks | 100 |
|  | Credits                                                                                                                                                                                                                                                        | 3                                                                                                                                                                                                                        | Exam Hours  | 3   |
|  | <b>Course Learning objectives:</b><br><br>To develop a focused inquiry into a specific area of algorithmic dynamics through formal content and theories with regards to emergent behaviours those exhibit a dynamic interaction of diverse forces.             |                                                                                                                                                                                                                          |             |     |
|  | <b>Module-1</b>                                                                                                                                                                                                                                                |                                                                                                                                                                                                                          |             |     |
|  | The subject focuses on the concepts and convergent interdisciplinary effects of evolutionary design processes on design and production technologies in architecture, the focus is on developing these as creative inputs to new architectural design processes |                                                                                                                                                                                                                          |             |     |
|  | <b>Teaching-Learning Process</b>                                                                                                                                                                                                                               | <i><b>ICT and Digital support:</b> Lecture will be conducted , through the use of powerpoint presentation</i>                                                                                                            |             |     |
|  | <b>Module-2</b>                                                                                                                                                                                                                                                |                                                                                                                                                                                                                          |             |     |
|  | The Subject Course is designed to familiarise students with these instruments, their associated conceptual fields and with their application to architectural design research.                                                                                 |                                                                                                                                                                                                                          |             |     |
|  | <b>Teaching-Learning Process</b>                                                                                                                                                                                                                               | <i><b>ICT and Digital support:</b> To introduce and understand different parameters and constraints to incorporate into the analysis and study of the project . power presentation for relevant studies and analysis</i> |             |     |
|  | <b>Module-3</b>                                                                                                                                                                                                                                                |                                                                                                                                                                                                                          |             |     |
|  | Course content includes theories of Generative algorithms within the realm of Emergence (swarm Behaviour, Fractals, L systems, cellular Automata, genetic algorithms). The concept ,various tools, building eggs should be analysed and studied                |                                                                                                                                                                                                                          |             |     |
|  | <b>Teaching-Learning Process</b>                                                                                                                                                                                                                               | <i><b>ICT and Digital support:</b> Lecture will be conducted , through the use of powerpoint presentation</i>                                                                                                            |             |     |
|  | <b>Module-4</b>                                                                                                                                                                                                                                                |                                                                                                                                                                                                                          |             |     |
|  | The course is meant to develop vocabulary and critical understanding of a wide array of algorithms, thus developing a critical stance towards algorithmic tooling.                                                                                             |                                                                                                                                                                                                                          |             |     |
|  | <b>Teaching-Learning Process</b>                                                                                                                                                                                                                               | <i><b>ICT and Digital support:</b> Lecture will be conducted , through the use of power point presentation</i>                                                                                                           |             |     |

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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Module-5</b>                                                                                                                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Research based theoretical investigations will also include works of architects who recursively use algorithmic tooling in their structural form finding and generative design processes. |
| <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>ICT and Digital support:</b> <i>Lecture will be conducted , through the use of power point presentation</i>                                                                            |
| <b>Assessment Details (both CIE and SEE)</b><br><p>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.</p> <p><b>Continuous Internal Evaluation:</b><br/>Continuous Internal Evaluation will be based on Assignments, Tests and Term Paper submission.</p> <p><b>Semester End Examination:</b><br/>Theory Examination shall be held for 3-hour duration, students are expected to answer FIVE full questions, one question from each module</p>                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                           |
| <b>Suggested Learning Resources:</b><br><b>Books</b> <ul style="list-style-type: none"> <li>• Tschumi, Bernard ; Notations: Diagrams and Sequences</li> <li>• Koolhaas, Rem ; Delirious New York: A Retroactive Manifesto for Manhattan, Fenton, Joseph , Pamphlet Architecture 11: Hybrid Buildings</li> <li>• Woodbury, Robert ; Elements of Parametric Design, Routledge New York</li> <li>• Tschumi, Bernard ; Event Cities</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                           |
| <b>Web links and Video Lectures (e-Resources):</b> <ul style="list-style-type: none"> <li>• <a href="https://www.researchgate.net/publication/282813761_Emergence_in_Architecture">https://www.researchgate.net/publication/282813761_Emergence_in_Architecture</a></li> <li>• <a href="https://www.youtube.com/watch?v=f6ra024-ASY">https://www.youtube.com/watch?v=f6ra024-ASY</a></li> <li>• <a href="https://www.techtarget.com/searchenterprisedesktop/definition/cellularautomaton#:~:text=A%20cellular%20automaton%20(CA)%20is,the%20states%20of%20neighboring%20cells.">https://www.techtarget.com/searchenterprisedesktop/definition/cellularautomaton#:~:text=A%20cellular%20automaton%20(CA)%20is,the%20states%20of%20neighboring%20cells.</a></li> <li>• <a href="https://www.re-thinkingthefuture.com/rtf-fresh-perspectives/a7137-fractal-geometry-in-architecture/">https://www.re-thinkingthefuture.com/rtf-fresh-perspectives/a7137-fractal-geometry-in-architecture/</a></li> <li>• <a href="https://www.sciencedirect.com/topics/engineering/swarmintelligence#:~:text=Swarm%20intelligence%20(SI)%20is%20a,movement%20of%20birds%20and%20fish.">https://www.sciencedirect.com/topics/engineering/swarmintelligence#:~:text=Swarm%20intelligence%20(SI)%20is%20a,movement%20of%20birds%20and%20fish.</a></li> </ul> |                                                                                                                                                                                           |
| <b>Skill Development Activities Suggested</b><br><p>The sessional work will be in the form of exercises that are based on generative processes using algorithmic tools available in grasshopper plugins and to understand its use in architectural design. The submission will also include research reports and theoretical presentations to explore the systematic investigation in design processes using algorithmic tools.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                           |

**Course outcome (Course Skill Set)**

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

| Sl. No. | Description                                                                                                                             | Blooms Level |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------|--------------|
| C01     | Students should be able to synthesize the knowledge they have acquired throughout the year.                                             | L2           |
| C02     | The students will be familiar with associated concepts of algorithmic architecture and its application to architectural design research | L3           |
| C03     | Advanced their knowledge on contemporary architectural discourse in close relation to the design task.                                  | L3           |
| C04     | To understand the comprehensive design , of a design project                                                                            | L4           |
| C05     | To establish new ways of thinking about design and fabrication, professional practice and its cultural impact.                          | L4           |

**Program Outcome of this program. (CPM)**

| Sl. No. | Description                                                                                                                                                             | POs |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 1       | Decoding the architectural design process as a collaborative, iterative and evolutionary vector framework                                                               | PO1 |
| 2       | The course/project goal is to increase the student's knowledge in this area/field and skills/knowledge in the field of architecture in general                          | PO2 |
| 3       | The students will enter the project with varying degrees of knowledge/skills and will subsequently end up at different levels at the end of the course/project.         | PO3 |
| 4       | The individual student must show an increase in the particular skills/knowledge offered and in the field of architecture in general                                     | PO4 |
| 5       | A framework is proposed as a disciplinary bridge to enable the team members to collaboratively identify and employ appropriate processes to implement morphogenetic IBs | PO5 |

**Mapping of COS and POS**

|     | PO1 | PO2 | PO3 | PO4 | PO5 |
|-----|-----|-----|-----|-----|-----|
| C01 | M   | M   | H   | H   | M   |
| C02 | M   | M   | L   | H   | M   |
| C03 | M   | M   | M   | H   | M   |
| C04 | L   | M   | M   | H   | L   |
| C05 | M   | M   | L   | H   | M   |

**H – High , M –Medium, L – Low**

**SEMESTER - II**

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |  |                                                                                                 |             |     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-------------------------------------------------------------------------------------------------|-------------|-----|
| DIGITAL FABRICATION AND MATERIAL COMPUTATION - II                                                                                                                                                                                                                                                                                                                                                                                                                                        |  |                                                                                                 |             |     |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |  | 2MDAC204                                                                                        | CIE Marks   | 50  |
| Teaching Hours per semester (L:T:P)                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  | 28:00:28                                                                                        | Term work   | 50  |
| Total Hours of Pedagogy                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  | 90 Hours                                                                                        | Total Marks | 100 |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  | 3                                                                                               | Exam Hours  | -   |
| <b>Course Learning objectives:</b><br><br>To augment contemporary developments in the computational design and advanced construction domain which display capacities to facilitate experimentation and investigation in material-informed architecture. The focus is to explore several intrinsic material properties and behavior dynamics, which can prove beneficial as primary drivers for generative, iterative morphological design developments and automated physical execution. |  |                                                                                                 |             |     |
| Module- 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  |                                                                                                 |             |     |
| Experimentation and investigation into a chosen structural or smart material wherein an in-depth study of the material's intrinsic physical properties (elasticity, anisotropy, hygroscopic behavior, structural limits) is comprehensively analyzed, tested, and digitally recorded.                                                                                                                                                                                                    |  |                                                                                                 |             |     |
| Teaching-Learning Process                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  | ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation |             |     |
| Module-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |                                                                                                 |             |     |
| The translation of documented physical material properties and live behavioral responses into numerical datasets, geometric constraints, and operational vectors, which are subsequently used to establish rule-based parametric setups and guide iterative digital generation.                                                                                                                                                                                                          |  |                                                                                                 |             |     |
| Teaching-Learning Process                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  | ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation |             |     |
| Module-3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |                                                                                                 |             |     |
| Establishing and deploying a tight cyber-physical feedback loop between digital simulation environments and analogue material experiments to augment design development based on specific, non-linear performance traits investigated during the studio.                                                                                                                                                                                                                                 |  |                                                                                                 |             |     |
| Teaching-Learning Process                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  | ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation |             |     |
| Module-4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |                                                                                                 |             |     |
| Advanced concepts of material discretization and manufacturing-ready geometric modeling: structural meshing, non-planar surface slicing, continuous vector sorting, topological optimization, structural folding, multi-axis toolpath generation (G-code/RAPID routing), and digital geometry reconstruction.                                                                                                                                                                            |  |                                                                                                 |             |     |
| Teaching-Learning Process                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  | ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation |             |     |

| Module-5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Advanced parametric modeling techniques and computer-aided manufacturing (CAM) tools: computational tools available to program fabrication hardware and model multi-axis setups will be introduced to construct automated relationships among complex structural parts. Lectures will focus on hands-on toolpath scripting techniques that can be applied directly to fabrication machinery to extend the efficiency, tolerance-control, and structural capacity of the execution process. |
| <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <i>ICT and Digital support: Lecture will be conducted, through the use of powerpoint presentation</i>                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Assessment Details (both CIE and SEE)</b><br><p>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.</p> <p><b>Continuous Internal Evaluation:</b><br/>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</p> <p><b>Semester End Examination:</b></p> <ul style="list-style-type: none"> <li>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.</li> <li>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.</li> <li>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.</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Suggested Learning Resources:</b><br><b>Books</b> <ul style="list-style-type: none"> <li>Peter Brandon; Emerging Paradigms and Models in Digital Design</li> <li>Performance-Based Architectural Design</li> <li>Menges, Achim; <i>Material Computation: Higher Integration in Morphogenetic Design</i>, Wiley.</li> <li>Peter Brandon; <i>Emerging Paradigms and Models in Digital Design: Performance-Based Architectural Design</i>.</li> <li>Michael Hensel ; Performance-Oriented Architecture: Rethinking Architectural Design and the Built Environment</li> <li>Stanney KM ; Handbook Of Virtual Environments : Design Implementation And Applications</li> <li>Braun ; Masterpieces: Performance Architecture + Design</li> <li>IncPadt; Introduction to the Ansys Parametric Design Language : A Guide to the Ansys Parametric Design Language</li> <li>Dunn, Nick; <i>Digital Fabrication in Architecture</i>, Laurence King Publishing</li> <li>Gramazio, Fabio and Kohler, Matthias; <i>Digital Materiality in Architecture</i>, Lars Müller publishers.</li> <li>.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Web links and Video Lectures (e-Resources):</b> <ul style="list-style-type: none"> <li><a href="https://www.youtube.com/watch?v=6meHDZMjp-I">https://www.youtube.com/watch?v=6meHDZMjp-I</a> (Advanced Material Synthesis S Computational Design Loops)</li> <li><a href="https://www.youtube.com/watch?v=WgvGv8OceLA">https://www.youtube.com/watch?v=WgvGv8OceLA</a> (Robotic Kinematics S Architectural Fabrication Systems)</li> <li><a href="https://www.youtube.com/watch?v=if8verABo2g">https://www.youtube.com/watch?v=if8verABo2g</a> (Material-Informed Digital Form-Finding S Execution)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

**Skill Development Activities Suggested**

The sessional work will include in-depth documentation of material experimentation that will specifically include intrinsic material properties documentation through demonstrative results, conversion of material properties into the digital medium and iterative digital explorations with reductive material parameters. The documentation will have material experimentation and prototypical models.

**Course outcome (Course Skill Set)**

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

| Sl. No. | Description                                                                                                                                          | Blooms Level |
|---------|------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| C01     | Characterize central digital fabrication technologies, material-computing methods, and multi-axis assembly systems.                                  | L2           |
| C02     | Interpret empirical material properties and seamlessly transfer them into functional algorithmic and structural digital models.                      | L3           |
| C03     | Critically review, plan, and assess the integration and strategic shift to digital fabrication within standard architectural construction pipelines. | L3           |
| C04     | Demonstrate the advanced use of computer-aided manufacturing (CAM) workflows and robotic toolpaths in complex computational design.                  | L4           |
| C05     | Master advanced workflows for tool-aided design, edge computation setups, and realtime cyber-physical feedback loops.                                | L4           |

**Program Outcome of this program. (CPM)**

| Sl. No. | Description                                                                                                                                                      | POs |
|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 1       | Assess what type or combinations of digital fabrication technologies, robotic setups, and custom material mixes are appropriate for the structural task at hand. | PO1 |
| 2       | Encompass the structural ability to orchestrate workflows in tight collaboration with interdisciplinary robotics and material engineering teams.                 | PO2 |
| 3       | Critically review, simulate, and troubleshoot the transition from descriptive geometric modeling to automated, performative material computation.                | PO3 |
| 4       | Analyze organizational, cost-efficiency, and design-to-production implications of deploying advanced digital fabrication on active construction sites.           | PO4 |
| 5       | Evaluate, synthesize, and strategically deploy composite fabrication machinery and generative scripts to maximize building component sustainability.             | PO5 |

**Mapping of COS and POS**

|     | PO1 | PO2 | PO3 | PO4 | PO5 |
|-----|-----|-----|-----|-----|-----|
| C01 | L   | M   | M   | M   | H   |
| C02 | L   | L   | M   | M   | H   |
| C03 | L   | M   | M   | M   | M   |
| C04 | M   | M   | L   | H   | M   |
| C05 | M   | M   | M   | H   | H   |

**H – High, M – Medium, L – Low**

## Semester- II

| PROFESSIONAL ELECTIVE- II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |                                                                                                        |             |     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--------------------------------------------------------------------------------------------------------|-------------|-----|
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  | 2MDAC205x                                                                                              | 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  | -   |
| <b>Course Learning objectives:</b><br><br>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 biological logic as an active computational driver, transitioning from superficial formal mimicking to the abstraction of natural principles, organic morphogenesis, multi-agent systems, and material-intelligence workflows.                                                                                                                                                                                                                                                                                                                                                                                                  |  |                                                                                                        |             |     |
| <b>2MDAC205A - BIO COMPUTATION AND BIOMIMETIC DESIGN</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  |                                                                                                        |             |     |
| <b>Module-1: Foundations of Biomimetics and Biological Morphology</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |  |                                                                                                        |             |     |
| <ul style="list-style-type: none"><li>• <b>Levels of Biomimetic Abstraction:</b> Distinguishing between organism, behavior, and ecosystem levels of biomimicry. Shifting from formal bio-morphism (copying natural shapes) to functional biomimetics (abstracting operational logic)</li><li>• <b>Biological Structural Typologies:</b> Investigating naturally occurring structural systems: skeletal frameworks, echinoid shells, cellular plant structures, and fiber-reinforced composite layouts.</li><li>• <b>Morphological Principles in Nature:</b> Analyzing anisotropic material distribution, scale-dependent behaviors, multi-functional surfaces, and structural redundancy in biological organisms.</li><li>• <b>Database Interoperability and Biological Translators:</b> Introduction to translating biological principles into engineering rules using international frameworks (such as the AskNature database, VDI 6220 guidelines, and morphological matrices).</li></ul> |  |                                                                                                        |             |     |
| <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |  | <i>ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation</i> |             |     |
| <b>Module-2: Bio-Computational Logic and Algorithmic Growth Morphogenesis</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |                                                                                                        |             |     |
| <ul style="list-style-type: none"><li>• <b>Algorithmic Growth Systems:</b> Scripting morphogenesis utilizing rule-based computational growth logic. Translating Lindenmayer Systems (L-systems) into structural branching networks.</li><li>• <b>Cellular Automata and Recursive Logic:</b> Deploying discrete cellular automata routines to simulate self-organizing spatial growth, structural layouts, and material density configurations.</li><li>• <b>Reaction-Diffusion and Pattern Formations :</b> Implementing Turing patterns and mathematical reaction-diffusion equations to generate differentiated surface textures, structural ribs, and acoustic paneling.</li><li>• <b>Anisotropic Form-Finding:</b> Writing scripts that dynamically vary geometric resolution, thickness, and porosity across a surface in response to local load and environmental vectors.</li></ul>                                                                                                    |  |                                                                                                        |             |     |
| <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |  | <i>ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation</i> |             |     |
| <b>Module-3: Swarm Intelligence and Multi-Agent Material Systems</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |  |                                                                                                        |             |     |
| <ul style="list-style-type: none"><li>• <b>Swarm Intelligence Principles:</b> Understanding emergent behavior through multi-agent computational frameworks. Analyzing flocking, schooling, and foraging rules found in social insects.</li><li>• <b>Agent-Based Modeling (ABM) for Architecture:</b> Setting up autonomous agents with discrete behavioral rules (attraction, cohesion, alignment) to generate complex path networks, fibers, and spaces.</li><li>• <b>Behavioral Material Deposition:</b> Simulating robotic material deposition paths through agent behaviors, mimicking the way silkworms, spiders, or weaver ants build structural enclosures.</li><li>• <b>Stigmergy and Local Feedback:</b> Implementing stigmergic coordination where simulated agents alter and respond directly to their digital environments, leading to self-assembling structural configurations</li></ul>                                                                                        |  |                                                                                                        |             |     |

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                        |
|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
|  | <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <i>ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation</i> |
|  | <b>Module-4: Bio-Fabrication, Material Intelligence and Living Materials</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                        |
|  | <ul style="list-style-type: none"> <li>• <b>Material Intelligence Workflows:</b> Designing with material systems that self-shape, expand, or adjust based on internal physical traits rather than external machine guidance.</li> <li>• <b>Biocomposites and Bio-Polymers:</b> Processing, printing, and characterizing bio-based building materials including mycelium networks, cellulose matrices, chitin structures, and algae gels.</li> <li>• <b>Hygroscopic Material Systems:</b> Designing kinetic, zero-energy building skins that open and close using the natural moisture-swelling traits of tailored wood veneers or bio-polymers.</li> <li>• <b>Additive Bioprinting Toolpaths:</b> Custom computational pipelines for extruding live, variable, or setting bio-mixtures. Managing shrinking factors, tool center offsets, and material curing requirements.</li> </ul>    |                                                                                                        |
|  | <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <i>ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation</i> |
|  | <b>Module-5: Evolutionary Optimization, Multi-Criteria Selection and Living Twins</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                        |
|  | <ul style="list-style-type: none"> <li>• <b>Genetic Algorithms in Nature and Design:</b> Mirroring evolutionary selection pathways by setting up fitness functions based on biological optimization rules.</li> <li>• <b>Multi-Criteria Optimization Loops:</b> Deploying evolutionary solvers to resolve competing structural, light, and material constraints, tracking historical genealogies over hundreds of generations.</li> <li>• <b>Bio-Hybrid Digital Twins:</b> Conceptualizing bidirectional feedback models where digital environments continuously parse sensory data from real-world biological systems or living building materials.</li> <li>• <b>Ecosystemic Integration and Scaling:</b> Evaluating how bio-computational design scales up to macro building components, discussing environmental lifecycles, degradability, and long-term carbon capture.</li> </ul> |                                                                                                        |
|  | <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <i>ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation</i> |

## Semester- II

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                        |
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| <b>2MDAC205B - BUILDING PERFORMANCE SIMULATION (BPS) and CARBON-NEUTRAL ARCHITECTURE</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                        |
| <b>Module-1: Thermodynamic Principles, Weather Data Curation and Climate Metrics</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                        |
| <ul style="list-style-type: none"> <li>The Carbon-Neutral Mandate: Analyzing international frameworks (Architecture 2030, Net-Zero Carbon Buildings Declaration, EN 15978 standard) targeting complete decarbonization of the built environment.</li> <li>Thermodynamic Principles of Buildings: Mastering heat transfer mechanisms (conduction, convection, radiation) through complex building envelopes. Microclimate variables and thermal balance equations.</li> <li>Weather File Data Curation: Deconstructing EnergyPlus Weather files (EPW) and Test Reference Years (TRY). Parsing global horizontal irradiance, direct normal irradiance, dew point profiles, and ambient wind matrices.</li> <li>Bioclimatic Diagnostic Frameworks: Translating raw climate datasets into adaptive comfort charts, psychrometric plots, and wind roses to define baseline, passive design scripts.</li> </ul> |                                                                                                        |
| <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>ICT and Digital support:</b> Lecture will be conducted , through the use of powerpoint presentation |
| <b>Module-2: Whole-Building Energy Modeling (BEM) and Thermal Zone Multi-Zoning</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                        |
| <ul style="list-style-type: none"> <li><b>Thermal Zone Partitioning:</b> Computational rules for abstracting complex 3D architectural models into multi-zone thermal networks. Setting boundary conditions: adiabatic, ground-coupled, and exposed surfaces.</li> <li><b>Construction Assemblage and U-Value Calibration:</b> Scripting layered construction assemblies with precise thermal mass, material conductivity, density, and specific heat metrics.</li> <li><b>Schedules and Operational Parameters:</b> Programming custom occupancy density layouts, equipment loads, lighting power densities (LPD), and HVAC operational patterns.</li> <li><b>Predictive Energy Use Metrics:</b> Simulating whole-building energy behavior to calculate annual Energy Use Intensity (EUI), Peak Heating/Cooling Loads, and operational utility configurations.</li> </ul>                                 |                                                                                                        |
| <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>ICT and Digital support:</b> Lecture will be conducted , through the use of powerpoint presentation |
| <b>Module-3: Dynamic Daylighting Engine Simulations and Solar Control Analytics</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                        |
| <ul style="list-style-type: none"> <li><b>Dynamic Daylight Metrics:</b> Shifting beyond static daylight factors to script Climate-Based Daylight Modeling (CBDM) routines. Simulating Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE).</li> <li><b>Visual Comfort and Glare Mechanics:</b> Computing Daylight Glare Probability (DGP) timelines over full annual distributions to establish spatial visual comfort matrices.</li> <li><b>Material Radiance Curation:</b> Mapping precise specular, diffuse, and transmissive material characteristics (Radiance material definitions) to glass, internal finishes, and external shading surfaces.</li> <li><b>Performance-Driven Aperture Scripts:</b> Authoring parametric facade louvers, static light shelves, and adaptive frits driven entirely by localized annual solar exposure patterns.</li> </ul>                           |                                                                                                        |

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|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>ICT and Digital support:</b> Lecture will be conducted , through the use of powerpoint presentation |
| <b>Module-4: Airflow Kinematics, Computational Fluid Dynamics (CFD) and Passive Cooling</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                        |
| <ul style="list-style-type: none"> <li>• Computational Fluid Dynamics for BPS: Setting up boundary layers, computational meshes, and turbulence parameters to model localized airflow velocities and pressure zones around envelopes.</li> <li>• Natural Ventilation and Stack Effect Mechanics: Simulating cross-ventilation patterns, wind-driven stack actions, and night-flushing sequences within multi-story architectural configurations.</li> <li>• Outdoor Microclimatic Comfort Maps: Applying the Universal Thermal Climate Index (UTCI) across site terrains to map outdoor comfort fields and thermal plume formations.</li> <li>• Passive Aerodynamic Volumetrics: Sculpting building volumes, lightwells, and indoor transition shafts based on predictive fluid dynamics to minimize active HVAC dependence.</li> </ul>                                                                            |                                                                                                        |
| <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>ICT and Digital support:</b> Lecture will be conducted , through the use of powerpoint presentation |
| <b>Module-5: Embodied Carbon, Life Cycle Assessment (LCA) and Multi-Objective Optimization</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                        |
| <ul style="list-style-type: none"> <li>• The Carbon Balance Equation: Defining the technical boundaries between Operational Carbon (CO<sub>2</sub> e emissions from energy use) and Embodied Carbon (emissions from material extraction, fabrication, and transport).</li> <li>• Life Cycle Assessment Methodology: Performing cradle-to-grave LCAs using international material inventories to quantify Global Warming Potential (GWP) and acidification impacts across structural frameworks.</li> <li>• Multi-Objective Evolutionary Optimization: Setting up genetic algorithm workflows to concurrently solve conflicting performance profiles (e.g., minimizing EUI and Embodied Carbon while maximizing sDA).</li> <li>• The Carbon-Neutral Dashboard: Consolidating operational energy, embodied carbon, and cost balances into a live computational interface for real-time design validation.</li> </ul> |                                                                                                        |
| <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>ICT and Digital support:</b> Lecture will be conducted , through the use of powerpoint presentation |

## Semester- II

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|  | <b>2MDAC205C - STRUCTURAL OPTIMIZATION AND GENERATIVE DESIGN</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                        |
|  | <b>Module-1: Algorithmic Form-Finding and Mathematical Tectonic Lineages</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                        |
|  | <ul style="list-style-type: none"> <li>• <b>The Paradigm of Material Minimums:</b> Tracing the transition from geometric imposition to behavioral form-finding. Analyzing historical lineages of graphic statics, physical hanging models, and minimal surface physics.</li> <li>• <b>Vector Mechanics and Force Equilibrium:</b> Mechanics of tension-only and compression-only spatial structures. Vector networks, internal stresses, bending moments, and geometric thrust lines under gravity.</li> <li>• <b>Computational Funicular Geometry:</b> Introduction to numeric form-finding methods: Force Density Method (FDM), Thrust Network Analysis (TNA), and particle-spring physics for spatial catenary systems.</li> <li>• <b>Interoperable Geometric Pipelines:</b> Setting up the file exchange path from parametric NURBS surfaces to discrete structural mesh networks configured for structural evaluation solvers.</li> </ul>                                          |                                                                                                        |
|  | <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <i>ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation</i> |
|  | <b>Module-2: Finite Element Analysis (FEA) and Computational Statics</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                        |
|  | <ul style="list-style-type: none"> <li>• <b>Principles of Finite Element Modeling:</b> Breaking down continuous 3D architectural geometry into discrete finite elements (1D beams, 2D shells, 3D solids). Defining mathematical node connection properties.</li> <li>• <b>Boundary Conditions and Loading Scenarios:</b> Setting up structural anchor points: pin, roller, fixed, and spring supports. Programming load combinations: self-weight, uniform live loads, localized point forces, and wind shear vectors.</li> <li>• <b>Mechanical Material Definitions:</b> Scripting linear isotropic, orthotropic, and anisotropic material properties (Modulus of Elasticity, Poisson's ratio, yield strength) for concrete, steel, engineered timber, and composites.</li> <li>• <b>Interpreting Performance Readouts:</b> Evaluating structural simulation maps: axial forces, shear-moment diagrams, displacement/deflection scales, and von Mises stress distributions.</li> </ul> |                                                                                                        |
|  | <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <i>ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation</i> |

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|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|--|
| Module-3: Structural Topology, Size, and Shape Optimization                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                 |  |
| <ul style="list-style-type: none"><li>• <b>Topology Optimization (TO) Mechanics:</b> Understanding Solid Isotropic Material with Penalization (SIMP) and Evolutionary Structural Optimization (ESO) rules. Removing low-stress material inside a defined spatial zone.</li><li>• <b>Shape and Size Optimization Pipelines:</b> Setting up parametric variables to alter structural cross-sections (beam depths, shell thickness gradients) and node locations to minimize material volumes while tracking deflection limits.</li><li>• <b>Stress-Line Tectonic Extraction:</b> Converting 3D stress trajectories and principal tension/compression vectors into explicit architectural rib patterns, columns, and variable-density panels.</li><li>• <b>Manufacturing Constraint Controls:</b> Integrating manufacturing limits (minimum member thicknesses, draft angles, 3D printing extrusion restrictions) directly into the mathematical topology solver.</li></ul> |                                                                                                 |  |
| Teaching-Learning Process                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation |  |
| Module-4: Evolutionary Computation and Multi-Objective Generative Exploration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                 |  |
| <ul style="list-style-type: none"><li>• <b>Genetic Algorithms for Design Evolution:</b> Setting up evolutionary solver loops based on natural selection. Defining variables (genes), geometric permutations (chromosomes), and performance goals (fitness functions).</li><li>• <b>Multi-Objective Optimization (MOO) Landscapes:</b> Simultaneously solving conflicting performance requirements (e.g., minimizing structural mass and deflection while maximizing daylight penetration or usable volume).</li><li>• <b>Evaluating the Pareto Frontier:</b> Navigating multi-variable data fields to select optimized design variants along the Pareto-optimal frontier. Analyzing generation histories and clustering patterns.</li><li>• <b>Automated Spatial Typology Generators:</b> Scripting rule-based generative engines (space syntax layout rules, fractal subdivision, voxel packing) that continuously feed variations into structural solvers.</li></ul>   |                                                                                                 |  |
| Teaching-Learning Process                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation |  |
| Module-5: Rationalization, Component Discretization and Digital Materialization                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                 |  |
| <ul style="list-style-type: none"><li>• <b>Geometric Tectonic Rationalization:</b> Converting double-curved structural shells into flat, planar quadrilateral facets or developable strip patterns to facilitate physical construction.</li><li>• <b>Automated Node and Connection Scripting:</b> Generating custom, variable joint layouts and interlocking connection details shaped entirely by localized structural force transfer requirements.</li><li>• <b>Material-Driven Design Feedback Loops:</b> Updating digital optimization files with real-world material traits, grain alignments, and tolerance errors to match production parameters.</li><li>• <b>The Structural Digital Twin Interface:</b> Mapping real-time structural sensor arrays (strain gauges, load cells) onto virtual finite element models to track performance variations over the lifespans of prototype assemblies.</li></ul>                                                         |                                                                                                 |  |
| 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:****Core Reference Books**

- Adriaenssens, S., Block, P., Veenendaal, D., S Williams, C. (Eds.). (2014). *Shell Structures for Architecture: Form Finding and Optimization*. Routledge.
- Bletzinger, K. U., S Ramm, E. (2014). *Structural Optimization in Architectural Design*. John Wiley S Sons.
- Menges, A. (2011). *Computational Design Thinking*. John Wiley S Sons.
- Caetano, I., Santos, L., S Leitão, A. (2020). *From Computational Design to Generative Design: Past, Present, and Future*. Springer.
- Shea, K. (2004). *Digital Tectonics: Structural Optimization and Informed Form-Generation*. Wiley-Academy.
- Wester, T. (2002). *Structural Morphology and Spatial Structures*. International Association for Shell and Spatial Structures.

**Web links and Video Lectures (e-Resources):**

- [Smart Geometry Open Research Network S Workshop Hub](#)
- [International Association for Shell and Spatial Structures \(IASS\)](#)
- [Karamba3D Parametric Engineering Research Platform](#)

**Skill Development Activities Suggested**

Assignment will be in the form of in depth documentation subsequent to the study of a topic related to any one of the subject based on availability of experts, which will be presented by the student in the form of a documented report, and a presentation on the same.

**Course outcome (Course Skill Set)**

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

| Sl. No. | Description                                                                                                                                                         | Blooms Level |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| C01     | To characterize central concepts of finite element arrays, funicular forms, genetic optimization setups, and topology rules.                                        | L2           |
| C02     | Enable students to understand engineering limitations and translation errors when moving from arbitrary forms to structurally optimized generative geometry.        | L2           |
| C03     | To develop skills in qualitative and quantitative load path calculation, stress trajectory extraction, and structural performance mapping.                          | L3           |
| C04     | To develop advanced understanding of multi-objective evolutionary solvers, Pareto frontier sorting, and mesh rationalization frameworks.                            | L3           |
| C05     | To critically interpret and apply structural optimization workflows toward resolved spatial assemblies, structural connections, and generative architectural forms. | L4           |

**Program Outcome of this program. (CPM)**

| Sl. No. | Description                                                                                                                                                                                                           | POs |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 1       | <b>Theoretical Relevance:</b> Understand the core historical and contemporary relevance of structural morphology, performative form-finding, and generative computation inside design theory.                         | P01 |
| 2       | <b>Workflow Limitations:</b> Gauge and document the technical boundaries, structural simplifications, and mathematical limits when moving physical force systems through digital evaluation engines.                  | P02 |
| 3       | <b>Data Synthesis:</b> Understand and master qualitative and quantitative material load combinations, internal strain records, and generational fitness metrics.                                                      | P03 |
| 4       | <b>Computational Application:</b> Develop a deep understanding of automated topology reduction layouts, parametric variable tracking, and recursive structural generation frameworks.                                 | P04 |
| 5       | <b>Critical Structural Interpretation):</b> Critically interpret, evaluate, and integrate computational optimization outlays with physical material processing, joinery layouts, and construction project conditions. | P05 |

**Mapping of COS and POS**

| Course Outcomes | P01 | P02 | P03 | P04 | P05 |
|-----------------|-----|-----|-----|-----|-----|
| C01             | H   | M   | L   | M   | H   |
| C02             | L   | H   | M   | M   | H   |
| C03             | L   | M   | M   | M   | H   |
| C04             | M   | L   | M   | M   | M   |
| C05             | L   | L   | M   | M   | H   |

H – High , M –Medium, L - Low

## Semester- II

| ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN ARCHITECTURE                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                        |          |             |     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|----------|-------------|-----|
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                        | 2MDAC206 | CIE Marks   | 50  |
| Teaching Hours per semester (L:T:P)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                        | 42:00:00 | Viva Marks  | 50  |
| Total Hours of Pedagogy                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                        | 90 Hours | Total Marks | 100 |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                        | 3        | Exam Hours  | -   |
| <b>Course Learning objectives:</b><br><br>To establish artificial intelligence and machine learning pipelines as major drivers for architectural design generation, prediction, and optimization decisions. The emphasis is to achieve an intelligent, data-driven feedback loop between spatial design ambitions, predictive neural networks, and generative AI models within the domain of computational and cognitive architecture.                                                                             |                                                                                                        |          |             |     |
| <b>Module- 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                        |          |             |     |
| Introduction to contemporary artificial intelligence frameworks and machine learning paradigms capable of processing architectural datasets. Core data-driven concepts: supervised, unsupervised, and reinforcement learning. Training neural networks to evaluate, analyze, and generate spatial data vectors. Introduction to deep learning histories, computer vision in the built environment, and the shift from geometric representation to algorithmic feature mapping.                                     |                                                                                                        |          |             |     |
| <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>ICT and Digital support:</b> Lecture will be conducted , through the use of powerpoint presentation |          |             |     |
| <b>Module-2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                        |          |             |     |
| Testing and training machine learning models on specific architectural datasets to predict structural stability, environmental metrics, thermal patterns, and spatial performance. Utilizing regression models and neural network classifiers to substitute heavy, time-consuming physical simulation engines. Streamlining multi-modal dataset preparation, data cleaning, image processing, and 3D voxelization techniques for design exploration.                                                               |                                                                                                        |          |             |     |
| <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>ICT and Digital support:</b> Lecture will be conducted , through the use of powerpoint presentation |          |             |     |
| <b>Module-3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                        |          |             |     |
| Introduction to deep generative models in architecture: Generative Adversarial Networks (GANs) for space layout mapping, Diffusion Models for conceptual iteration, and Variational Autoencoders (VAEs) for structural form-finding. Facilitating spatial layout generation using text-to-image, image-to-image, and text-to-3D computational pipelines. Instructing students on how to extract structural features and run real-time aesthetic and spatial configuration checks using neural networks.            |                                                                                                        |          |             |     |
| <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>ICT and Digital support:</b> Lecture will be conducted , through the use of powerpoint presentation |          |             |     |
| <b>Module-4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                        |          |             |     |
| Advanced neural network applications and specialized spatial AI frameworks. These platforms are taught to students through short specialized seminars, inviting relevant industry experts, computer scientists, and practitioners to delve deeper into specific toolkit integration: ControlNet configurations, LoRA training, Graph Neural Networks (GNNs) for Space Syntax, RunwayML, Stable Diffusion APIs, grasshopper-integrated ML plugins (e.g., Owl, LunchBox ML, Ameba), and semantic segmentation tools. |                                                                                                        |          |             |     |

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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Module-5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Application of the gained artificial intelligence and machine learning knowledge to complex architectural design problems. Using trained neural networks to find optimized spatial layouts, structural topology solutions, and multi-objective performance forms. Understanding the deep structure, data-flow logic, and systemic workflow of custom machine learning models to drive automated, highly efficient, and innovative architectural designs. |                                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Teaching-Learning Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                         | <i>ICT and Digital support: Lecture will be conducted , through the use of powerpoint presentation</i> |
| <p><b>Assessment Details (both CIE and SEE)</b></p> <p>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.</p> <p><b>Continuous Internal Evaluation:</b></p> <p>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</p> <p><b>Semester End Examination:</b></p> <ul style="list-style-type: none"> <li>• 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.</li> <li>• 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.</li> <li>• 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.</li> </ul> <p><b>Suggested Learning Resources:</b></p> <p><b>Books</b></p> <ul style="list-style-type: none"> <li>• Peter Brandon; Emerging Paradigms and Models in Digital Design Performance-Based Architectural Design</li> <li>• Michael Hensel ; Performance-Oriented Architecture: Rethinking Architectural Design and the Built Environment</li> <li>• Stanney K M ; Handbook Of Virtual Environments : Design Implementation And Applications</li> <li>• Braun ; Masterpieces: Performance Architecture + Design</li> <li>• IncPad; Introduction to the Ansys Parametric Design Language : A Guide to the Ansys Parametric Design Language</li> <li>• Chaillou, Stanislas; <i>Artificial Intelligence and Architecture: From Research to Practice</i>, Birkhauser.</li> <li>• Leach, Neil; <i>Architecture in the Age of Artificial Intelligence: An Introduction to AI for Architects</i>, Bloomsbury Visual Arts.</li> <li>• Del Campo, Matias; <i>Neural Architecture: Design and Artificial Intelligence</i>, ORO Editions.</li> <li>• Goodfellow, Ian, Bengio, Yoshua and Courville, Aaron; <i>Deep Learning</i>, MIT Press.</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                        |

**Web links and Video Lectures (e-Resources):**

- <https://www.youtube.com/watch?v=6meHDZMjp-I> (Machine Learning Workflows S Dataset Preparation)
- <https://www.youtube.com/watch?v=WgvGv8OceLA> (Deep Neural Networks S Generative Design Processes)
- <https://www.youtube.com/watch?v=if8verABo2g> (AI Deployment S Parametric Software Interfacing)

**Skill Development Activities Suggested**

The students will be asked to make presentations about the role of performance based design using a specific simulation tool that they have learnt in the due course introduced to them. Through small exercises the students will apply their parametric knowledge and performance assessment to a building typology. Students are expected to submit detailed reports of the tutorials they undertook with appropriate analysis of the results.

**Course outcome (Course Skill Set)**

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

| Sl. No. | Description                                                                                                                              | Blooms Level |
|---------|------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| C01     | Synthesize advanced data-driven knowledge, neural network frameworks, and dataset principles acquired throughout the year.               | L2           |
| C02     | Understand and implement associated concepts of predictive modeling, feature tracking, and deep architecture networks.                   | L3           |
| C03     | Master the core structures, algorithmic pipelines, and cross-platform workflows of generative AI modeling.                               | L3           |
| C04     | Manipulate complex multi-dimensional data flows and model loss constraints toward desired predictive design outcomes.                    | L4           |
| C05     | Master machine learning program flow, Python programming libraries, and model weight manipulation inside Rhino/Grasshopper environments. | L4           |

**Program Outcome of this program. (CPM)**

| Sl. No. | Description                                                                                                                                                | POs |
|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 1       | Possess the critical data-literacy skills necessary to question the architectural limits, data biases, and ethical dimensions of an AI software interface. | PO1 |
| 2       | Encompass the professional ability to work in close technical collaboration within cross-disciplinary software development and data science teams.         | PO2 |
| 3       | Critically review, configure, and assess machine learning model outputs and apply them strategically to architectural design resolution.                   | PO3 |
| 4       | Develop a rigorous, highly specialized design sensibility for generative, algorithmic modeling uniquely suited for smart spatial environments.             | PO4 |
| 5       | Enable students to achieve a advanced understanding of artificial intelligence tools that aid in computational and cognitive design.                       | PO5 |

**Mapping of COS and POS**

|     | PO1 | PO2 | PO3 | PO4 | PO5 |
|-----|-----|-----|-----|-----|-----|
| C01 | M   | M   | H   | H   | M   |
| C02 | M   | M   | L   | M   | H   |
| C03 | H   | H   | M   | L   | H   |
| C04 | M   | M   | M   | M   | H   |
| C05 | L   | L   | L   | M   | H   |

H High , M Medium, L - Low

— — — END OF SEMESTER — — —