

Executive Diary

Integrated Computational Engineering @IIT Hyderabad

Dr Saswata Bhattacharya, Dr Niranjan Ghaisas & Prof Raja Banerjee (L-R)
IIT Hyderabad
KID: 20210403

With the advent of digital manufacturing and Industry 4.0, India foresees a rapid surge in the use of digital technologies such as Artificial Intelligence, High Performance, and Cloud Computing, Internet of Things, etc. spanning across industrial sectors ranging from aerospace, automobile all the way to biotechnology and healthcare. An important aspect of Industry 4.0 is a strongly networked and integrated Cyber-Physical System and automation of the workplace with a high dependency on Artificial Intelligence. In the past few decades, India has developed strong bachelor's and master's programs in Computer Science and Information Technology that have spawned globally competitive IT and ITES industries. Although India is known for its robust programs in core engineering disciplines, modern industries rely on computational tools to design and analyze products and processes to create a digital twin. To address this need from the Industry, new curricula should be developed to produce highly trained, skilled human resources that can develop and implement computer models and simulation tools. Such manpower will complement the already existing skilled workforce trained in traditional core engineering disciplines.

Modern education needs to be more interdisciplinary in nature and prepare graduates who can rapidly conform to the ever-changing job market. This has also been emphasized in the National Education Policy, 2020, according to which all modern curricula should be cognizant to the requirement of the rapidly evolving industry needs. IIT Hyderabad has always been at the forefront in developing new and flagship programs e.g., undergraduate and postgraduate programs in AI and Mathematics and Computing. It has recently introduced one new undergraduate and two new postgraduate programs with the intent to create such a skilled workforce that will develop and apply engineering software to solve cutting-edge problems in engineering.

BTech in Computational Engineering

Computational Engineering is envisaged to be an interdisciplinary program. Fig. 1 shows the four major components in the curriculum layout of Computational Engineering. These include (a) Applied Mathematics, (b) Core Engineering, (c) Data Structures & Analytics, and (d) Computational Applications **(Fig. 1).** Through these four pillars of the program, the student will gain proficiency not only to develop and apply various computational methodologies but also to get trained in important topics of core engineering so that the bridge between computational solutions and physical principles is established.

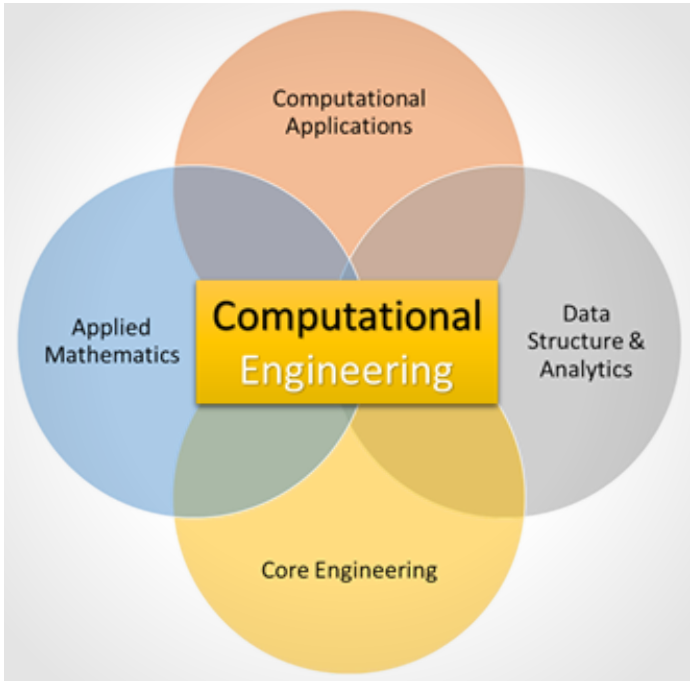

Fig. 1: Program Layout

This curriculum is designed keeping in mind the T **shape**. The breadth of the curriculum is achieved from courses in Core Engineering and Applied Mathematics that will help the students learn fundamental concepts of core engineering subjects and the associated mathematics. The **Depth** of the curriculum is achieved by introducing the students to various computational methods that include fundamentals in scientific computing, data structures, and analytics, and the design and application of computational tools. The **breadth** courses are expected to give insight into the fairness of the solutions obtained using the methodologies taught in the depth courses. Hence, the depth courses need to be supplemented by the breadth courses. **Fig. 2** illustrates this unique design of the curriculum.

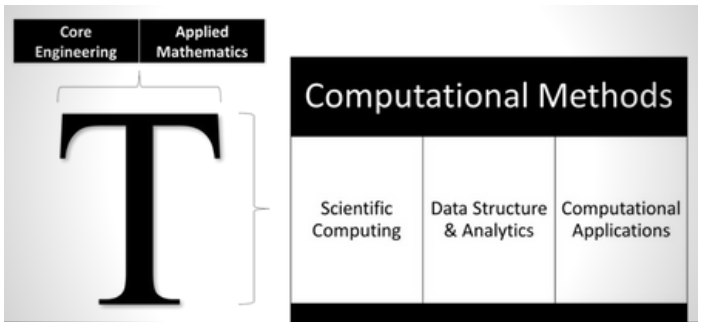

Fig. 2: The T design

MTech program in ICME

The Master's program in Integrated Computational Materials Engineering (ICME) is a unique interdisciplinary program designed exclusively for professionals working in industries and research organizations. The purpose of this program is to teach professionals from various industries an accelerated approach to design materials and products concurrently and synergistically. This course aims to teach the principles of materials design, modeling tools at multiple length scales and timescales **(Fig.3)**, and their applications in linking processing-structure-property-performance relations in materials to address issues related to product design and application.

MTech program in Computational Mechanics

The online MTech in Computational Mechanics is a unique program offered by the Department of Mechanical and Aerospace Engineering @IITH which will train students to solve multidisciplinary problems related to mechanical systems using computational techniques. The program combines elements of numerical methods and scientific computing with fundamental principles in solid mechanics, fluid mechanics, design, and vibrations **(Fig. 4)**. Graduates of this online MTech program will be well equipped to address technological challenges in industries in the automotive, oil and natural gas, renewable energy, defence, and manufacturing sectors.

Research in Integrated Computational Engineering

In IIT Hyderabad, faculty are actively engaged in research and development in various aspects of Integrated Computational Engineering. More than fifty faculty are actively engaged in research related to various disciplines of computational engineering including computational biology, process modeling, optimization and control, high-performance computing, FEA, CFD, materials modeling, etc. This has resulted in over 1400 journal and conference publications and close to 180 PhD. students (inclusive of graduated and ongoing). Recently the institute Data Centre has been substantially revamped to cater to the growing needs of faculty's computational research. Additionally, an 800 TFlop state-of-the-art HPC cluster, Param Seva, has been commissioned under the aegis of the National Supercomputing Mission. This will substantially boost high-fidelity computational modeling and simulations and will help in cutting-edge research in this field.

Vision for the future

IIT Hyderabad has made a concentrated effort in teaching and research in the field of Integrated Computational Engineering. Several groups in IITH are engaged in developing sophisticated computational tools that will immensely help in the advancement of the digital capital of the country. Through this effort at IITH with Industry as stakeholders, we envision a sustainable and innovative ecosystem that will generate human and knowledge capital for the country.

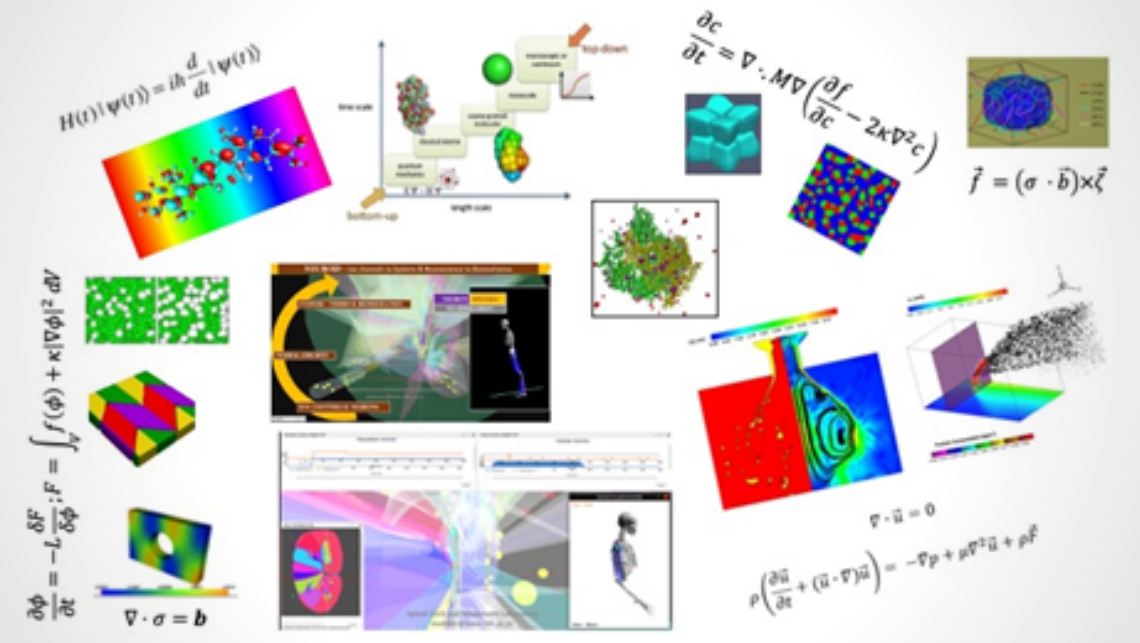

Fig. 3: Multiscale Materials Design

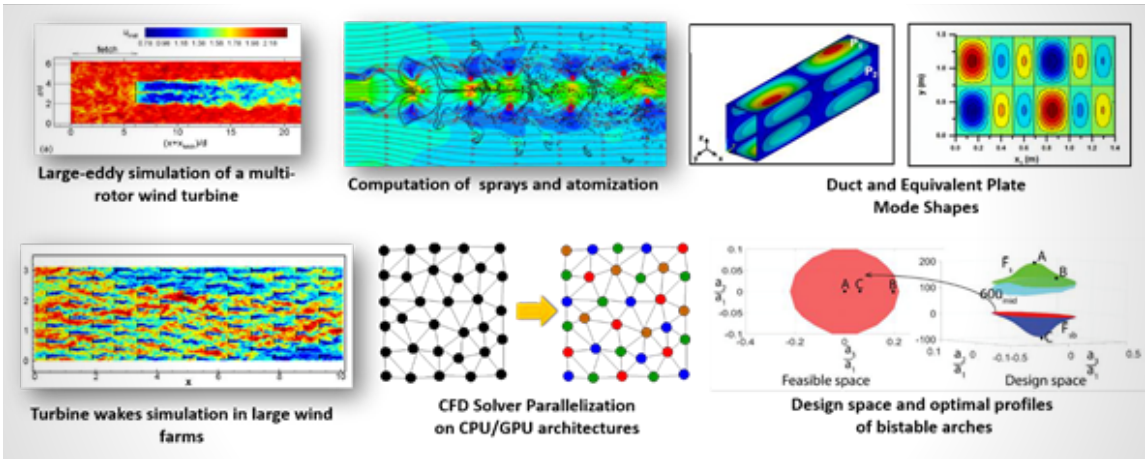

Fig. 4: Elements of Computational Mechanics