Semester IV

DISCIPLINE SPECIFIC ELECTIVE COURSE -2 (DSE-2)
IV.4.5. Mathematical modelling & Simulation

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Mathematical modeling & simulation# DSE-2, IV.4.5	**4**	**0**	**0**	**4**	**12th pass with Maths**	**Linear Algebra, Differential Equations**

 # This course will also be available to the students in semester VI

Learning Objectives

This interactive learning module intends to provide capabilities and basic understanding of system modelling and simulation performance. It will emphasis on analysis of dynamical behavior of physical, electrical, mechanical, social, biological, chemical, and financial systems along with applications in engineering and other applied sciences. The simulation will be done with the MATLAB software platform.

Learning outcomes

- After completing this course, student should be able to;
- Understand the mathematical and computational tools for modelling and simulation of various systems.
- Apply basic concepts of fractional calculus.
- Identify, model analyze, and simulate various systems using simulation tools.
- Know how the simulation help to analyze system graphically.
- Describe the behavior of different physical and virtual systems.

Syllabus

Practicals – (120 Hours)

- Modeling of integer and non-integer systems
- Introduction to basic simulation tools
- Simulation performance of integer and non-integer systems
- Chaotic behavior of integer and non-integer systems
- Parameter optimization to improve the efficiency of the system
- Model validation and performance analysis with data

● Innovation Project

Essential/recommended readings

- Theory of modeling and simulation, Zeigler B.P., Praehofer. H., Kim I. G., 2nd Edition. Academic press, 2000.
- Theory of Fractional Dynamic Systems, Lakshmikantham, V., Leela, S., Vasundhara Devi,
  J. Cambridge Academic Publishers, Cambridge, 2009.
- Fractional-order nonlinear systems: modeling, analysis and simulation, Petras, I., SpringerVerlag Berlin Heidelberg, Germany, 2011.
- Chaos: An Introduction to Dynamical Systems, K.T. Alligood, Sauer, Tim D., Yorke James
  Springer, 1996.
- Nonlinear Dynamics and Chaos, Strogatz, S. Reading, MA: Addison-Wesley, 1994.
- Optimization and Dynamical Systems, Helmke U., Moore J. B, SpringerVerlag, 1993.

DISCIPLINE SPECIFIC ELECTIVE COURSE -2 (DSE-2)
IV.4.6. Computational Fluid Dynamics (CFD)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Computational Fluid Dynamics# (CFD), DSE-2, IV.4.6	**4**	**0**	**0**	**4**	**12th Pass With Maths**	**Calculus, Linear Algebra & Differential Equations**

#This course will also be available to the students in semester VI

Learning Objectives

This interactive practical paper aims to enable the students to visualize different types of problems of flow and heat transfer in various fields. Blood flow within arteries, biological tissues, heat transfer within biological tissues, flow within circular pipes, flow within an aquifer are some of the important application of CFD. In this paper, students will visualize CFD models, mathematical analysis of these visualizations, simulate them numerically using mathematical softwares such as ANSYS, COMSOL and post process the obtained numerical results.

Learning Outcome

After completing this paper, students will be able;

- Visualise and implement mathematical models of flow and heat transfer problems in different applications.
- Implement existing CFD based modules in ANSYS/COMSOL for simulation purpose.
- Design of UDF based problem specific modules in ANSYS/COMSOL
- Validate their numerical results with experimental data (if available) for suggesting new designs.

Syllabus

Practicals - (120 Hours)

- Governing equations for CFD: The continuity, momentum and energy equations with their physical interpretation
- Interpretation of different set of flow conditions such as inflow, outflow, no slip boundary etc as per problem requirement.
- CFD mesh generations, structured and unstructured mesh, mesh refinement (local & global), adaptive mesh.
- Implementation of existing CFD based modules in ANSYS/COMSOL for simulation purpose.
- Design and modification of existing modules using UDF (User defined functions) in ANSYS/COMSOL as per the problem requirement.
- Post-processing of numerically simulated results

Essential/ Recommended Readings:

- Computational Fluid Dynamics: A practical Approach (2019) by Jiyuan Tu, Guan Yeoh, Chaoqun Liu, 2nd Edition, Publisher: Butterworth-Heinemann.
- Computational Fluid and Particle Dynamics in the Human Respiratory system (2012) by Jiyuan Tu, Kiao Inthavong, Goodarz Ahmadi, Biological and Medical Physics, Bio-medical Engineering, Publisher: Springer.
- Multiphysics Modelling using COMSOL: A First Principle Approach (2011), by Roger W. Pryor, Jones and Bartlett Publishers, London, Singapore.

DISCIPLINE SPECIFIC ELECTIVE COURSE -2 (DSE-2)
IV.4.7. Technology based solutions of societal issues

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Technology based solutions of societal issues, DSE-2, IV.4.7	**4**	**0**	**0**	**4**	**12th pass**	**Programming Fundamentals, Basic knowledge of biology.**

#This course will also be available to the students in semester VI

Learning Objectives

This course is designed for students to give them hands-on experience of working on interdisciplinary research problems, which may have direct impact or relevance for the linkage of society and technology. This will broaden their horizon regarding the identification of an issue and then step by step way of solving the same, either theoretically or experimentally by acquiring the required technology-based skill-sets.

Learning outcomes

After completing this course, student should be able to;

- Identify a research problem related to a societal issue, which may be solved using technology
- Acquire the required technical skill-sets, which will be needed for solving such problems
- Get the hands-on training for working on real societal issues requiring technology-based interventions, so that students can become more sensitive and responsible for solving such issues

Syllabus

Practicals – (120 hours)

- Developing an understanding related to societal issues specifically in the sectors of water, food, electricity, textiles, housing, energy, defense and human health etc., which may require a technology-based intervention
- Identification of a problem as per interest of the student, and solving it using innovative and interdisciplinary approaches
- Working on problems based on artificial intelligence-based biosensors, Electrochemical biosensors, wearable biosensors etc. for various applications related to society
- Building machine learning models on various datasets specially related to health issues for the identification, diagnosis or prediction of the disease
- Computational modeling/ simulation of nanoparticles and their usage in drug delivery applications for various diseases. Examples can be like neuro-simulation of

drug-loaded nanoparticles for understanding the pathway for diseases like mental depressive disorders.

Essential/recommended readings

- Sensing and Artificial Intelligence Solutions for Food Manufacturing; Editors: Charles Oluwaseun Adetunji, Daniel Hefft, CRC Press
- Mathematical Modeling of Biosensors by Romas Baronas, Felikas Ivanauskas, Juozas Kulys, (2021); Springer International publishing
- Biosensors and Nanotechnology: Applications in Health Care Diagnostics (2017), Editor: Zeynep Altintas; Wiley Publishers
- Research papers/ Reviews from peer reviewed reputed journals, related to the identified problem/ issue

DISCIPLINE SPECIFIC ELECTIVE COURSE -2 (DSE-2)
IV.4.8. Medical Imaging Techniques

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Medical Imaging Techniques#, DSE-2, IV.4.8	**4**	**0**	**0**	**4**	**12th Pass**	**Basic knowledge of python**

#This course will also be available to the students in semester VI

Learning Objectives

This practical paper is designed to provide hands on experience to build data driven module for computer vision, with applications in medical image analysis. This practical paper enables the students to build deep learning architecture, such as filters, activation functions, loss functions; regularization techniques such as e.g. batch normalization and dropout. Student can implement different non-linear optimization algorithms that are used when training the medical imaging networks on different imaging tools.

Learning outcomes

- Training and validation of image dataset, classification and regression, supervised and unsupervised learning, bias and variance, loss function, generalization error, accuracy, precision, to medical image dataset.

- Can implement deep learning parameters, such as e.g. depth, learning rate, hyper parameter, overtraining and regularization in softwares.
- Implementation of different deep learning architecture for classification and segmentation of diagnosis of various diseases.
- Can simulate hybrid deep learning architecture and models used in medical imaging.

Syllabus

Practicals - (120 Hours)

- Implementation of basic Medical imaging tools.
- Feature extraction, segmentation, systematic evaluation and validation on medical image datasets using data driven architectures.
- Designing different machine learning and deep learning based models for segmentation and classification of medical imaging datasets.
- Performance analysis of different deep learning architecture in terms of statistical parameters.
- Case studies on some recent advances in analysis of retinal, CT, MRI, ultrasound and histology images.

Essential/recommended readings

1. The Handbook of Medical Image Perception and Techniques, by Ehsan Samei and Elizabeth A. Krupinski, second edition, Publisher Cambridge University Press.
2. Medical Imaging by DS Guru, K.C. Santosh, Nilanjan Dey, Sameer Antani, Publisher CRC Press.

DISCIPLINE SPECIFIC ELECTIVE COURSE -2 (DSE-2)
IV.4.9. Virtual Reality

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Virtual Reality#, DSE 2, IV.4.9	4	0	0	4	Class XII pass with Maths	C^{++}

#This course will also be available to the students in semester VI

Learning Objectives

The objective of this course is to provide a detailed understanding of the concepts of Virtual Reality and its applications

Learning outcomes

At the end of the course, the students will be able to:

- Understand geometric modelling and Virtual environment.
- Be able to do 2D and 3D geometrical modelling
- Develop Virtual Reality applications.

Practicals - (120 Hours)

The course will be conducted completely on a hands-on mode and project-based learning. The basic concepts will be explained and each concept will be augmented by small tasks in UNITY.

Animations and physical simulations will be introduced to the students through an appropriate Virtual environment. Following tasks will be covered in the lab:

- Introduction to the Virtual environment
- Introducing frame of reference and modelling transformations
- Animation in virtual environment – projectile motion, flight/ car simulation, Ferris wheel, pendulums, etc.
- Visualising Human Anatomy/ geographical regions/ environment/ monuments in the VR environment
- Modelling a store/ classroom/ office/ mall in VR

Essential/recommended/ suggested readings

- Virtual Reality Systems, John Vince, Pearson Education India, 2002. https://all3dp.com/2/blender-3d-printing-tutorial/
- Understanding Virtual Reality: Interface, Application and Design, William R Sherman and Alan B Craig, Morgan Kaufmann, 2018
- Virtual Reality, Samuel Greengard, MIT Press, 2019.
- Virtual and Augmented Reality, Paul Mealy, Wiley, 2018.