

VISVESVARAYA NATIONAL INSTITUTE OF TECHNOLOGY, NAGPUR

Name of Certification: Post Graduate Diploma

Course Title: Post Graduate Diploma in Computer Aided Engineering

Proposed Maximum Duration: 1 year

Total Hours: 480 hours

Mode of course delivery: Hybrid

Offered by: V. R. Jamdar Siemens Center of Excellence, VNIT Nagpur (Mechanical Engineering)

Eligibility: B.Tech (Mechanical) Completed / M.Tech (Mechanical Engineering) Ongoing

Course Objective:

1. Ability to create and modify 3D models and assemblies, and generate technical drawings and schematics.
2. Gain expertise in using Finite Element Analysis (FEA) software to analyze and optimize the structural integrity and performance of complex engineering systems, such as aircraft, automobiles, or industrial equipment.
3. Learn how to use Computational Fluid Dynamics (CFD) software to simulate fluid flow and heat transfer in complex systems, such as engines, turbines, and heat exchangers.
4. Understand the principles of engineering simulation and modeling, and gain experience in using simulation software tools to model and optimize various types of systems.

Course Structure:

Year	Sem	Course Code	Course Name	L	T	P	Credits
First	1 st	PGDCAE401	Simcenter 3D essentials	0	0	6	3
First	1 st	PGDCAE 402	Mathematics for FEA and CFD	2	1	0	3
First	1 st	PGDCAE 403	Simcenter 3D Advanced Simulation	3	1	0	4
First	1 st	PGDCAE 404	Simcenter 3D Advanced Flow Analysis	1	0	6	4
First	1 st	PGDCAE 405	Simcenter 3D Advanced Thermal Analysis	0	0	6	3
First	1 st	PGDCAE 406	Multistep nonlinear Analysis	3	0	0	3
Sub Total							20
First	2 nd	PGDCAE 407	Simcenter 3D Laminate Composites	0	0	6	3
First	2 nd	PGDCAE 408	Simcenter 3D Motion analysis	1	0	6	4
First	2 nd	PGDCAE 409	Simcenter 3D Battery Management System	2	0	6	5
First	2 nd	PGDCAE 410	Professional Development	1	0	2	2
First	2 nd	PGDCAE 411	Industrial Case Study	0	0	0	3
First	2 nd	PGDCAE 412	Mini Project	0	0	0	3
Subtotal							20
Total							40

Course outcomes:

1. Students will develop advanced skills in using CAD, CAM, FEA, and CFD software tools, and gain expertise in applying these tools to design, analyze, and optimize complex engineering systems.
2. Students will develop strong problem-solving abilities, including the ability to identify and diagnose engineering problems, and to develop effective solutions using computer-aided engineering tools and techniques.
3. Graduates of this program may have increased employment opportunities in fields such as aerospace, automotive, manufacturing, and civil engineering, where advanced CAD and CAE skills are in high demand.
4. Students will develop effective communication skills, including the ability to explain complex engineering concepts and designs to colleagues, clients, and stakeholders.
5. Students will gain increased confidence in their technical skills and ability to tackle complex engineering problems, which can help them succeed in their careers and professional development.

Attendance: As per institute rule book. (100 % mandatory, 25% relaxation may be given by course coordinator)

Course Evaluation: Mid-term (30%) + End Term(30%) + Teacher's Assessment (40%)

Course Fees: Rs. 48,000 + 18% GST

Course Proposed by VRJSCOE Team to BoS (Interdisciplinary)**Course Coordinators:**

Prof. A. B. Andhare
(Professor Incharge, Test and Optimization Lab of VRJSCOE)

Dr. Ashwin S. Dhoble
(Professor Incharge, Test and Optimization Lab of VRJSCOE)

Dr. Ritesh Kesari
(Associate Professor, Department of Electrical Engineering)

Lab Coordinator(s):

Trainers for Test and Optimization Lab of VRJSCOE Lab of VRJSCOE and Center Manager

Course Execution Coordinator:

Prof. Shital S. Chiddarwar
Center Head
V R Jamdar Siemens CoE

Syllabus:

Syllabus for PGDCAE401-Simcenter 3D essentials – (0-0-6-3)

1. Introduction to Simcenter 3D, an overview of the software suite, its capabilities and the various modules that are available.
2. Understanding the Simcenter 3D interface and its customization options
3. Geometry Import and Manipulation, geometry file formats, manipulation of geometry using variety of tools for use in simulations.
4. Meshing techniques available in Simcenter 3D.
5. The different types of boundary conditions, and how to set them up in Simcenter 3D.
6. Solvers in Simcenter 3D for structural, fluid and thermal analysis, selection of solvers, configuration of solvers for different simulation scenarios.
7. Post-processing tools in Simcenter 3D.
8. Simulation Automation using various automation tools available in Simcenter 3D.
9. Advanced Topics like optimization, fatigue analysis, and multiphysics simulations

Text book:

1. Simulations with NX / Simcenter 3D: Kinematics, FEA, CFD, EM and Data Management, Reiner Anderl , Peter Binde , Hanser Publications; 2nd edition (September 10, 2018)

Syllabus for PGDCAE 402-Mathematics for FEA and CFD:

1. Linear Algebra: Vectors and Matrices, Matrix operations, Matrix inversion, Determinants, Eigenvalues and Eigenvectors.
2. Calculus: Limits and continuity, Differentiation, Partial differentiation, Integration, Multiple integrals, and Vector calculus.
3. Differential Equations: First-order ordinary differential equations, Second-order ordinary differential equations, Systems of ordinary differential equations, Partial differential equations.
4. Numerical Methods: Root-finding methods, Interpolation and extrapolation, Numerical integration, Numerical differentiation, Finite difference methods, Finite volume methods, and Finite element methods.
5. Partial Differential Equations: mathematical description of fluid and solid mechanics given by partial differential equations, derivation of these equations and their physical interpretations.
6. FEA: the basics of Finite Element Analysis (FEA) would be introduced, including the discretization of the domain, element types, shape functions, interpolation functions, and integration.
7. CFD: the basics of Computational Fluid Dynamics (CFD), including governing equations, discretization methods, turbulence modeling, boundary conditions, and post-processing.
8. Applications: application of FEA and CFD in various engineering fields, such as structural analysis, heat transfer, fluid flow, and electromagnetics.

Text Books:

1. Numerical Methods for Engineers, Steven C. Chapra and Raymond P. Canale , 7th edition, McGraw Hill Education, 2010
2. An Introduction to Finite Element Method, J. N. Reddy , 7th Edition, McGraw Hill Education, 2017
3. Numerical Heat Transfer and Fluid Flow, Suhas V. Patankar, CRC Presss, 2017

Syllabus for PGDCAE 403-Simcenter 3D Advanced Simulation

1. Introduction to Advanced Simulations, an overview of advanced simulations and their importance in engineering design and development.
2. Nonlinear Analysis: Nonlinear analysis of structures that undergo large deformations, contact, and material nonlinearity the different types of nonlinear analyses available in Simcenter 3D.
3. Multiphysics Simulation, the modeling and simulation of multiphysics problems, such as fluid-structure interaction, thermal-mechanical coupling, and electromagnetic-thermal coupling.
4. Optimization, optimization techniques available in Simcenter 3D, including topology optimization, shape optimization, and parameter optimization.
5. Acoustics, analysis of noise and vibration in products and structures, the modeling and simulation of acoustic problems in Simcenter 3D.
6. Composites, modeling and simulation of composite structures in Simcenter 3D.
7. Fatigue Analysis and fatigue analysis techniques available in Simcenter 3D.

Text books:

1. Simulations with NX / Simcenter 3D: Kinematics, FEA, CFD, EM and Data Management, Reiner Anderl , Peter Binde , Hanser Publications; 2nd edition (September 10, 2018)
2. Simcenter 3D Advanced Simulation user guide, Siemens PLM, https://docs.plm.automation.siemens.com/data_services/resources/scnastran/2020_1/help/tdoc/en_US/pdf/adv_dynamics.pdf

Syllabus for PGDCAE 404-Simcenter 3D Advanced Flow Analysis:

1. Introduction to Advanced Flow Analysis, its importance in engineering design and development.
2. Advanced Meshing Techniques in Simcenter 3D, such as hexahedral meshing, polyhedral meshing, and unstructured meshing, and their benefits for flow analysis.
3. Turbulence Modeling, turbulence models available in Simcenter 3D, such as Reynolds-averaged Navier-Stokes (RANS), Large Eddy Simulation (LES), and Detached Eddy Simulation (DES).
4. Combustion Modeling in Simcenter 3D, such as non-premixed and premixed combustion models.
5. Multiphase Flow Analysis such as liquid-gas, solid-liquid, and gas-liquid-solid flow, different multiphase flow models available in Simcenter 3D.
6. Heat Transfer Analysis to simulate heat transfer processes in fluids and structures, different heat transfer models available in Simcenter 3D, such as conduction, convection, and radiation.

Text books:

1. Computational Fluid Dynamics: Principles and Applications, Jiri Blazek, Butterworth-Heinemann; 3rd edition, 2015
2. Turbulence Modeling for CFD, David C. Wilcox, DCW Industries, 2006
3. Multiphase Flow Handbook (Mechanical and Aerospace Engineering Series), Efstathios E. Michaelides, CRC Press, 2nd edition, 2016
4. Simcenter Flow Solver Reference Manual by Siemens

Syllabus for PGDCAE 405- Simcenter 3D Advanced Thermal Analysis

1. Solar Heating, critical aspect of thermal analysis for sustainable energy systems, solar heat transfer and its modeling and simulation in Simcenter 3D.
2. Radiative Heating, radiative heat transfer modeling and simulation in Simcenter 3D.
3. Advanced Thermo-Optical Properties, anisotropic emissivity and index of refraction, thermo-optical properties modeling and simulation in Simcenter 3D.
4. Duct Networks used in heating, ventilation, and air conditioning (HVAC) systems, modeling and simulation of duct networks in Simcenter 3D.
5. Supersonic Flow Boundary Condition the modeling and simulation of supersonic flow boundary conditions in Simcenter 3D.
6. Rotating Frames of Reference using Simcenter 3D.
7. Rotational and Translational Periodicity, modelling and simulation of rotational and translational periodicity in Simcenter 3D.
8. Advanced Thermal Coupling Types, conductive, convective, and radiative, and their modeling and simulation in Simcenter 3D.
9. Active Fan Controller, modeling and simulation of active fan controllers in Simcenter 3D.
10. Non-Newtonian Fluids and its modeling and simulation of in Simcenter 3D.
11. Humidity and Scalar Fluid Mixtures and its Simcenter 3D.
12. Peltier Cooler (TECs), Joule Heating, Ablation and Charring and their the modeling and simulation of Joule heating in Simcenter 3D.

Text books:

1. Simulations with NX / Simcenter 3D: Kinematics, FEA, CFD, EM and Data Management, Reiner Anderl , Peter Binde , Hanser Publications; 2nd edition (September 10, 2018)
2. Simcenter 3D Advanced Thermal Analysis Siemens User guide, https://docs.plm.automation.siemens.com/data_services/resources/scnastran/2020_1/help/tdoc/en_US/pdf/thermal.pdf

1. Introduction to Nonlinear FEA, Overview of Nonlinear Analysis, Advantages and Limitations, Multi-step Solution Sequences in Simcenter 3D
2. Nonlinear Dynamics, Linear vs. Nonlinear Dynamics, Time Domain Analysis, Frequency Domain Analysis, Modal Analysis using Simcenter 3D
3. Contact, Types of Contact, Contact Modeling Techniques, Contact Analysis Examples using Simcenter 3D
4. Large Displacements and Large Strains, Kinematics of Large Deformation, Strain Measures, Large Displacement Analysis, Large Strain Analysis using Simcenter 3D
5. Plasticity / Hyperelasticity / Creep, Constitutive Modeling of Nonlinear Materials, Plasticity Modeling, Hyperelasticity Modeling, Creep Modeling using Simcenter 3D
6. Nonlinear Boundary Conditions, Load and Displacement Control, Nonlinear Analysis Examples using Simcenter 3D
7. Debugging Nonlinear Solutions, Solution Techniques, Convergence Issues, Post-processing Techniques in Simcenter 3D

Text books:

1. Multistep nonlinear Analysis using Simcenter 3D, User guide, https://docs.plm.automation.siemens.com/data_services/resources/scnastran/2020_1/help/tdoc/en_US/pdf/multistep_guide.pdf

1. Introduction to laminate composite simulation, Zone-based process, Ply-based process
2. Modeling 3D laminates using Simcenter 3D Laminate Composites
3. Material properties for laminate plies, Material Property Definition, Material Testing and Characterization, Material Property Assignment
4. Solving and post-processing, Solution Techniques, Convergence Issues, Post-processing Techniques, using Simcenter 3D Laminate Composites
5. 2D laminate theory, Classical Lamination Theory, Stiffness and Compliance Matrix, Strain and Stress Calculation, using Simcenter 3D Laminate Composites
6. Laminate failure analysis, Failure Criteria, Failure Analysis Techniques, Post-failure Analysis, using Simcenter 3D Laminate Composites
7. Laminate dynamics solution process, Dynamic Analysis Setup, Frequency and Modal Analysis, Transient Analysis, using Simcenter 3D Laminate Composites
8. Laminate optimization, Design Space Definition, Objective Function and Constraints, Optimization Techniques and Algorithms, using Simcenter 3D Laminate Composites

Text Books:

1. Simcenter 3D Laminate Composites, User Manual by Siemens
https://docs.plm.automation.siemens.com/data_services/resources/nx/1899/nx_help/custom/en_US/samcef_solver_documentation/index.html

1. Using the basic capabilities of SIMCENTER 3D Motion, Performing kinematic, dynamic analysis of Motion models, Preparing models that can be used in Motion, Creating motion bodies, joints, specialized constraints, and motion drivers, Defining a mechanism with springs, dampers, bushings
2. Using various data tools to work with Motion models, Adding loads to a Motion model, Defining analytical contact and 3D contact for a Motion model, Defining Motion solution options, Displaying Motion results, Using sub mechanisms to define a mechanism
3. Combine rigid bodies (links), joints, and motion drivers to create a mechanism and set it into motion, Manage multiple motion simulations, Apply forces, torques, springs, dampers, bushings, and contact in a motion simulation, Query a motion simulation for information and edit both model and simulation features
4. Apply packaging options to generate feedback in the form of marker and component tracing, critical measurements, and interference checking, use spreadsheets and graphing to both animate and analyze a motion simulation, Use advanced solutions to simulate component flexibility, transfer loads for a finite element analysis, and control an electric motor

Text book

1. https://docs.plm.automation.siemens.com/tdoc/nx/1872/simcenter_3d_tutorials.html#uid:index_xid1391716
2. Simulations with NX / Simcenter 3D: Kinematics, FEA, CFD, EM and Data Management, Reiner Anderl , Peter Binde , Hanser Publications; 2nd edition (September 10, 2018)

- Introduction to Battery Management Systems, overview of battery management systems, their functions, and the importance of battery management systems in modern electric and hybrid vehicles.
- Simcenter 3D Battery Management System Overview, introduction to the Simcenter 3D Battery Management System software, its capabilities, and its user interface.
- Battery Modeling, different types of battery models available in Simcenter 3D BMS, including equivalent circuit models, physics-based models, and machine learning-based models.
- Battery State Estimation, different techniques used to estimate the state of charge, state of health, and state of power of a battery and how Simcenter 3D BMS implements these techniques
- Battery Control, control strategies used to manage the charging and discharging of a battery, as well as the thermal management of the battery, implementation of these strategies using Simcenter 3D BMS.
- Battery Safety, safety mechanisms implemented in Simcenter 3D BMS to prevent battery failure, such as overcharging, overheating, and short circuits.
- Case Studies of how Simcenter 3D BMS has been used to design and analyse battery systems for different applications, such as electric vehicles, hybrid vehicles, and stationary energy storage systems.
- Hands-on Exercises, UI and make changes to the cell design, set up and run multiple simulations with a physics-based (Distributed) model, fit equivalent circuit (NTG and RCR) models, simulate thermal abuse and its impact on battery safety using Simcenter 3D BMS

Text Books:

1. Simcenter Amesim Reference guide, Leuven, Siemens Industry Software NV, 2020.
2. Real-Time Simulation User's guide, Leuven, Siemens Industry Software NV, 2020.
3. Battery Management Systems, Volume I: Battery Modeling, Gregory L. Plett, Artech House, 2015
4. Battery Management Systems, Volume II: Equivalent-Circuit Methods, Gregory L. Plett, Artech House, 2015
5. Battery Management Systems, Volume III: Physics based modeling, Gregory L. Plett, Artech House, 2023

Introduction to Professional Development for Engineers, The need for lifelong learning in engineering, The benefits of professional development for engineers

Developing Technical Skills, The importance of staying up-to-date with technical skills, Strategies for developing technical skills, such as attending training programs, online courses, and industry conferences

Effective Communication, The importance of effective communication in the engineering profession, Strategies for improving communication skills, such as public speaking, technical writing, and interpersonal communication

Leadership and Management, the importance of leadership and management skills in the engineering profession, Strategies for developing leadership and management skills, such as taking on project management roles, attending leadership training programs, and learning about team building

Ethics and Professionalism, The importance of ethical behavior and professionalism in the engineering profession, Strategies for developing ethical and professional behavior, such as attending ethics training programs, learning about professional organizations, and networking with other professionals

Career Planning and Development, The importance of setting career goals and developing a plan to achieve them, Strategies for career planning and development, such as networking, seeking mentorship, and exploring different career paths within the engineering profession

Workplace Issues, The importance of understanding workplace issues such as workplace diversity, conflict resolution, and work-life balance, Strategies for addressing workplace issues and creating a positive work environment

Professionalism in the Digital Age, The importance of understanding digital professionalism and online communication, Strategies for managing your online presence and using social media to advance your professional goals

Text Books:

1. Strategies and Tips for Time Management, Jack Barrett
2. How to Win Friends & Influence People, Dale Carnegie
3. Start with why, Simon Sinek

PGDCAE 411 - Industrial Case Study (0-0-0-3) : Candidate has to present a live case study covering all aspects of software Simcenter 3D. Presentation and report submission will be mandatory.

PGDCAE 412 - Mini Project (0-0-0-3) : Candidate has to take a live problem from industry, implement various tools of Simecenter 3D to solve it. Presentation and report submission will be mandatory.