



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Aeronautical Engineering

Subject Code: BE04001011

Subject Name: Parametric Design and Geometric Modelling

w.e.f. Academic Year:	2024-25
Semester:	4
Category of the Course:	Professional Core Course

Prerequisite:	Zeal to learn the subject
Rationale:	This course provides students with the necessary skills to create, analyze, and manipulate geometric models, apply computational methods for stress and deformation studies, and evaluate aerospace components and assemblies. By integrating theoretical concepts with practical CAD/FEA tools, the course bridges the gap between engineering fundamentals and real-world aerospace applications.

Course Outcomes:

Sr. No.	CO statement	Marks% weightage
CO-1	Demonstrate basic concept of computer aided design and its applications.	20
CO-2	Make use of various concepts and characteristics in geometric modeling.	25
CO-3	Analyze geometric transformations.	20
CO-4	Determine stress and strain in structural elements through FEA.	25
CO-5	Demonstrate the applications of Industry 4.0 in aerospace design and manufacturing.	10

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
L	T	P	PBL*	Total no of hours per semester		Theory		Tutorial / Practical			
						ESE (E)	PA / CA (M)	PA/C A (I)	PBL (I)	ESE (V)	
45	0	60	15	120	4	70	30	20	30	50	200

* Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.



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Content:

Sr. No.	Content	Total Hrs
1	Introduction Typical aerospace product cycle overview, Conventional Design V/s CAD, CAD Input/output devices, Coordinate systems (working, model, screen), Line and circle generation algorithms (DDA, Bresenham's), Graphics exchange standards and database management.	05 Hours
2	Geometric Transformations Geometric transformations (translation, scaling, reflection, rotation, shearing), 2D and 3D transformation, Homogeneous coordinates representation, Concatenated representation, Orthographic and perspective projections, Window-to-viewport Mapping, Aerospace visualization and model manipulation examples	08 Hours
3	Mathematical Representation of Curves Parametric representations: lines, circles, ellipses, parabolas, hyperbolas, Synthetic curves: continuity, cubic spline, Bezier curves, Properties of B-Splines and NURBS, Types of surfaces and aerospace applications (wing profiles, fuselage shapes)	06 Hours
4	Geometric Modelling Geometry and topology fundamentals, Comparison of various geometrical modelling techniques, Properties of solid model, Solid modelling schemes: B-rep, CSG, Sweep representation, cell decomposition, octree encoding, Applications to aerospace components and assemblies	06 Hours
5	Parametric Design Parametric design principles and its importance in design processes, Parametric modeling vs conventional modeling, Use of constraints and relationships in geometry creation and modification, Applications in adaptive design of wings, fuselage sections, and control surfaces, Case studies on parametric airfoil design.	06 Hours
6	Finite Element Analysis Stress-strain review, generalized Hooke's Law, Plane stress/strain concepts, Total potential energy method, FEA procedure, 1-D analysis: shape functions, stiffness matrix, displacement and stress analysis using elimination and penalty methods, Uniaxially loaded beam problems, Stiffness matrix for trusses, solution of trusses using FEA, 1-D thermal and fluid problems, Aerospace structural FEA examples (wing, fuselage, truss structures)	12 Hours
7	Industry 4.0 Introduction, Various building blocks of Industry 4.0, Applications in aerospace field	02 hours
TOTAL		45



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Suggested Specification table with Marks (Theory): (For B.E. only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
30	20	10	10	10	20

R: Remembrance; U: Understanding; A: Application; N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guide line for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. **Zeid, I.** – *Mastering CAD/CAM*, McGraw-Hill.
2. **Groover, M.P. & Zimmers, E.W.** – *CAD/CAM: Computer-Aided Design and Manufacturing*, Pearson.
3. **Mortenson, M.E.** – *Geometric Modeling*, Wiley.
4. **Foley, J.D., van Dam, A., Feiner, S.K., Hughes, J.F.** – *Computer Graphics: Principles and Practice*, Addison-Wesley.
5. **Donald Hearn & M. Pauline Baker** – *Computer Graphics with OpenGL*, Pearson.
6. **Belegundu, A.D. & Chandrupatla, T.R.** – *Introduction to Finite Elements in Engineering*, Pearson.
7. **Cook, R.D., Malkus, D.S., Plesha, M.E., Witt, R.J.** – *Concepts and Applications of Finite Element Analysis*, Wiley.
8. **Logan, D.L.** – *A First Course in the Finite Element Method*, Cengage.
9. **Zienkiewicz, O.C., Taylor, R.L. & Zhu, J.Z.** – *The Finite Element Method: Its Basis and Fundamentals*, Elsevier.
10. **Krishnamurthy, C.S.** – *Finite Element Analysis: Theory and Programming*, Tata McGraw-Hill.

List of Experiments:

1. Study of CAD system components, input/output devices, and graphics displays.
2. Implementation of line/circle generation algorithms (DDA and Bresenham's).
3. Introductory exercise for 3-D modelling.
4. Exercise for advanced 3-D modelling.
5. Exercise for 3-D editing features.
6. Exercise for Assembly modelling.
7. Exercise for FEA of 1-D structural problems.
8. Exercise on modeling and analysis of simple truss structures for nodal displacements and member forces.
9. Exercise on plane stress problem using FEA.
10. 1-D thermal conduction analysis using FEA method.
11. Static structural analysis of aerospace component (wing rib, fuselage panel) using FEA software.



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Major Equipment:

- Computers/Workstations
- CAD Software
- FEA Software

List of Open Source Software/learning website:

CAD & Modeling

- FreeCAD – Open-source 3D parametric modeler for product design.
- Blender – Open-source tool for 3D modeling and visualization (suitable for rendering aerospace models).
- OpenCASCADE – Geometry kernel for CAD/CAM/CAE development.
- LibreCAD – Open-source 2D CAD software for drafting.

FEA & Simulation

- Code_Aster – Open-source FEA software (structural, thermal, multi-physics).
- CalculiX – Open-source FEA software (supports nonlinear problems, aerospace structures).
- OpenFOAM – Open-source CFD package (aerospace fluid dynamics).

Learning Websites

- NPTEL (IITs online courses) – Free aerospace CAD/CAE/FEA courses (<https://nptel.ac.in>)

List of suggested activities for Term Work / Self Learning:

Activities suggested under self-learning:

Sl. No.	Name of the activity	No. of hours	Evaluation Criteria
1.	Industry/Research laboratory visit	Visit = 5h, Report preparation = 5h Total = 10h	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
2.	Technical Video based learning related to the subject	Duration of video = 5h Report preparation = 5h Total = 10h	Report /presentation based on the video learning outcomes.
3.	Assignment writing. Numericals based assignment is preferable.	5 assignments of 2h each. Total = 10h	Based on the assignment submitted.
4.	Problem solving/Coding using C, C++, Python, SCILAB, MATLAB, MS-EXCEL or any other relevant software	5 small coding based assignment of 2h each. Total = 10h	Based on the coding solution submitted.
5.	Self learning on-line course	Minimum duration of the course should be 10h.	Examination based assessment at the end of course. Based on the certificate produced.
6.	Complex problem solving	Maximum 2 problem. Study of the problem and solution finding, Total = 10h	Based on the depth of the solution submitted.



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7	Videos on Industrial safety aspects based on subject	Duration of video = 5h Report preparation = 5h Total = 10h	Based on quiz/report submitted
8	Discussion on research paper based on relevant subject	5 research paper = 20 h	Summarize research paper and evaluation critical parameters
9.	Poster/chart/power point preparation on technical topics	Duration = 6 h	Based on poster/chart preparation and presentation skills
10	Working/non-working model on technical topics	Working = 12 h Non- working = 8 h	Based on inter department/external evaluation
11	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/any other issue	Duration = 15 h for industrial exposure Problem identification and tentative solution = 10 h Total = 20 h	Based on evaluation of critical problems and solutions
12	Group Discussion on emerging/trending technical topics based on subject	Duration = 1 h each	Based on performance in group discussion, technical depth, knowledge etc.
13.	Real world case studies-based learning	Duration of data collection/study = 5h Report preparation = 5h Total = 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.
14.	Application/Software development	Duration = 10 h	Depending on the complexity of the Application/Software

Note:

1. All the suggested activity should be related to the subject.
2. The number of hours are suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
3. Rubrics for the evaluation can be prepared by the faculty.
