Gyanmanjari Innovative University

Course Syllabus
Gyanmanjari Institute of Technology
Semester-4 (B.Tech)

Subject: Aerodynamics-I- BETAE14307

Type of course: Professional Core

Prerequisite: Basic Knowledge of Fluid Mechanics, aircraft components, lift, drag and flight forces.

Rationale: The Aerodynamics course provides essential knowledge on the behavior of airflow around aircraft and other bodies, focusing on the generation of lift, drag, and aerodynamic forces. It equips students with the theoretical and practical skills needed to analyze and optimize aircraft performance, stability, and efficiency. The course is fundamental for understanding aircraft design, flight mechanics, and the impact of aerodynamic principles on real-world aerospace applications.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks					Total Marks
CI	T	P	C	Theory Marks		Practical Marks		CA	
				ESE	MSE	V	P	ALA	
4	0	2	5	60	30	10	20	30	150

Legends: CI-Classroom Instructions; T – Tutorial; P - Practical; C – Credit; ESE - End Semester Examination; MSE- Mid Semester Examination; V – Viva; CA - Continuous Assessment; ALA- Active Learning Activities.

Course Content:

Unit No	Course content	Hrs.	% Weightage
1	**Low speed Aerodynamics:** Aerodynamic forces and moments, Incompressible Flow in a duct: The Venturi and Low-Speed Wind Tunnel, Pitot Tube: Measurement of Air Speed, Pressure coefficient, Centre of pressure and aerodynamic center, Effect of incidence on pressure distribution, the lift Curve, Airfoil stalling, Drag, Types of drag, Drag Polar, Alembert's Paradox, pitching moment, Span wise Flow variation, Downwash.	15	25 %
2	**Potential Flow:** Angular Velocity, Vorticity and Strain, Circulation, Kutta Joukowsky Theorem, Stream Function, Velocity Potential, Elementary flows: Uniform flow, Source Flow, Doublet Flow, Vortex Flow, Principles of Superposition, Combination of uniform flow with a source and sink, half body, Rankine oval body, non-lifting flow over circular cylinder, lifting flow over a cylinder.	15	25 %
3	**Thin Airfoil Theory:** Low speed flow over an Airfoil - Vortex Sheet, The Kutta Condition, Kelvin's Circulation Theorem, and Classical Thin Airfoil Theory - The Symmetrical Airfoil, The Cambered Airfoil and Viscus Flow: Estimating Skin Friction Drag, Transition, Flow Separation, The Vortex Panel Numerical Method for Lifting flow over bodies. **Finite Wings:** Introduction: Downwash and Induced Drag, The vortex filament, The Biot-Savart Law and Helmholtz's Theorem. Prandtl's classical lifting line theory. Elliptical lift distribution, General Lift distribution, Effect of Aspect Ratio. Numerical Lifting line method. Lifting surface and VLM, Applied aerodynamics over the delta wing	22	40 %
4	**Applications of High Lift Systems:** Introduction to high-lift systems, flaps, leading-edge slats and typical high – lift characteristics. Effects of thickness, camber and aspect ratio of wings, tip effects.	8	10 %

Continuous Assessment:

Sr. No	Active Learning Activities	Marks
1	**Airfoil & Airspeed Analysis** Each student must draw the airfoil assigned by the faculty, add sample Cp values, and plot a basic Cp or lift-curve graph to study lift, drag, and stall. They must also draw a small Venturi or Pitot-tube diagram and write 4–5 lines on how airspeed is measured. The final work should be combined into one PDF and uploaded on the GMIU portal	10
2	**Demonstration for Downwash & Induced Drag** Students will work in a small group to create a simple visual demonstration of downwash or wingtip vortices using a paper/cardboard wing in front of a fan and capture a photo or screenshot as evidence. The group will draw a clear diagram showing induced drag, lift distribution, or the effect of aspect ratio, and write a few easy lines explaining Prandtl's lifting-line concept. All photos, diagrams, and explanations must be combined into one PDF and uploaded on the GMIU portal	10
3	**Case Study of a Selected Aircraft** Each student has to choose any one aircraft (A320, 737, Tejas, glider, etc.) and write a small explanation of the flaps, slats, and other high-lift parts used on that aircraft. They also have to draw one labelled sketch showing how these parts help the aircraft create more lift during takeoff and landing. A short note on how wing thickness, camber, and aspect ratio change the lift must be added. The whole work should be made into one PDF and uploaded on the GMIU portal.	10
	Total	30

Suggested Specification table with Marks (Theory):60

Distribution of Theory Marks (Revised Bloom's Taxonomy)						
Level	**Remembrance (R)**	**Understanding (U)**	**Application (A)**	**Analyze (N)**	**Evaluate (E)**	**Create (C)**
Weightage	30%	40%	30%	-	-	-

Course Outcome:

After learning the course, the students should be able to:	
CO1	Explain low-speed aerodynamic behaviour related to forces, pressure, lift, drag, stall, and measurements.
CO2	Apply potential-flow concepts to analyse ideal aerodynamic bodies
CO3	Analyse airfoil and wing aerodynamics to evaluate lift, drag, and downwash.
CO4	Evaluate high-lift systems and wing-geometry effects on lift enhancement and aerodynamic performance.

List of Practical:

Sr. No	Descriptions	Unit No	Hrs.
1	**Study of Wind Tunnel and Its Components:** To study the construction, operation, and calibration of a low-speed wind tunnel and understand its working principles and flow measurement techniques.	1	4
2	**Measurement of Airspeed Using a Pitot-Static Tube:** To measure dynamic, static, and total pressure using a Pitot-static tube and calculate airspeed using Bernoulli's equation.	1	4
3	**Flow Visualization Over an Airfoil and Cylinder:** To visualize streamlines and flow separation over airfoils and cylinders using smoke or tuft methods in a wind tunnel.	1	2
4	**Determination of Pressure Distribution Over a Cambered Airfoil:** To determine pressure distribution, lift, and moment coefficients for a cambered airfoil and identify the aerodynamic center.	1	4
5	**Study of Boundary Layer and Flow Separation:** To measure the boundary layer thickness on a flat plate and observe the effect of Reynolds number on flow separation.	2	2
6	**Pressure Coefficient Distribution over an Airfoil:** To measure pressure distribution over the upper and lower surfaces of an airfoil and compute pressure coefficient (Cp) at various chord wise stations.	2	2
7	**Determination of Induced Drag and Downwash Over a Finite Wing:** To study downwash distribution and induced drag on a finite wing using experimental or computational techniques.	3	4

8	**Measurement of Downwash and Induced Drag on a Finite Wing:** To measure downwash behind a finite wing and determine the induced drag at a given lift condition.	3	2
9	**Study of High-Lift Devices (Flaps and Slats) and Their Effect on Lift Characteristics:** To determine the effect of trailing-edge flaps and leading-edge slats on the lift coefficient and stall angle of an air foil.	4	2
10	**Study of Lift and Drag Characteristics of an Airfoil:** To determine lift and drag forces using a balance system and plot lift and drag curves with varying angles of attack.	4	4
		Total	30

Instructional Method:

The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.

From the content 10% topics are suggested for flipped mode instruction.

Students will use supplementary resources such as online videos, NPTEL/SWAYAM videos, e-courses, Virtual Laboratory

The internal evaluation will be done on the basis of Active Learning Assignment

Practical/Viva examination will be conducted at the end of semester for evaluation of performance of students in laboratory.

Reference Books:

[1] "Fundamentals of Aerodynamics" by John D Anderson

[2] "Aerodynamics for Engineering" Students by E L Houghton and P W Carpenter

[3] "Aerodynamics" by L J Clancy | Sterling Book House Indian Edition

[4] "Theoretical Aerodynamics" by Milne Thomson

[5] E. L. Houghton, P.W. Carpenter, Aerodynamics for Engineering Students, 5th edition, Elsevier, New York.