FUNDAMENTALS OF THEORETICAL AND EXPERIMENTAL AERODYNAMICS

PROF. ARNAB ROY
Department of Aerospace Engineering
IIT Kharagpur

INTENDED AUDIENCE : Aerospace Engineering/ Mechanical Engineering
INDUSTRIES APPLICABLE TO : This course should suit as an introductory Aerodynamics course for new recruits in organizations like National Aerospace Laboratory (NAL), Defence Research and Development Laboratory (DRDL), Aeronautical Development Agency (ADA), Aeronautical Development Establishment (ADE), Hindustan Aeronautics Limited (HAL) and private/ multinational aerospace firms like Boeing, Airbus etc. It should be useful for IAF engineers and pilots as well..

COURSE OUTLINE :
This course is introductory in nature and expected to impart firsthand knowledge of Aerodynamics. It combines fundamentals of theoretical and experimental aspects of Aerodynamics without making it too intense and detailed. After successful completion of this course the student should be well prepared for more advanced courses in the discipline.
With ever increasing use of Aerodynamics in a wide gamut of applications like drones, UAVs, micro air vehicles, automobile aerodynamics, sports aerodynamics, industrial aerodynamics, defence and space, it is essential to understand the basics or quickly refresh the fundamental concepts of Aerodynamics while working on any of the above applications. This course exactly fulfils that need.
I would like to once more emphasize that the primary intention of this course is to create a familiarity about Aerodynamics. It is not intended to prepare someone for research but induce the excitement and enthusiasm to pursue it further.

ABOUT INSTRUCTOR :
1. I am currently working as Professor at the Department of Aerospace Engineering, IIT Kharagpur. The above weblink provides my research details.

2. I have taught various courses covering Aerodynamics, introductory and advanced courses in CFD, Wind Tunnel Design and Testing as well as a few courses in Aerospace Propulsion at IIT Kharagpur to UG/ PG and PhD students.On almost all occasions I have received an overall student feedback rating between 4 and 5 (on a scale of 5). In all, I have about 16 years teaching experience at UG and PG levels combined.

3. My research interests include computational and experimental fluid dynamics. I am also involved in aerospace propulsion research. I have undertaken and executed projects for different organizations like AOARD (Japan), Boeing (USA), AR&DB, DLJ-DRDO, RDSO, ISRO, DST etc

4. I have delivered several CFD related invited lectures at GE Aviation JFWTC, Bangalore (2019); CFD Workshop, BITS Pilani Hyderabad campus (2016); 13th Aeronautical Society of India Annual CFD Symposium at IISc Bangalore (2011),Indo US INDUS-MAV Workshop at Bangalore,organized by NAL and ADE Bangalore (2009) etc.

COURSE PLAN :

Week 1 : Aerodynamics-relevance and applications ,Atmosphere · Flow velocity, pressure, skin friction ,Generation of aerodynamic forces and moments on an aircraft , Aircraft external shape and surfaces

Week 2 : Eulerian and Lagrangian perspectives of flow, Fluid Kinematics, Conservation equations of mass, momentum and energy

Week 3 : Inviscid and viscous flows- potential flow, boundary layer, Compressible and incompressible flow, Laminar and turbulent flow

Week 4 : Airfoil geometry, Pressure distribution at an angle of attack (α), Aerodynamic centre, centre of pressure, Cl- α, Cl-Cd, Cm-α curves, Flow separation and stall, High lift devices, multi element airfoils, Laminar and turbulent flow over airfoil, Trailing edge noise

Week 5 : Finite wing geometry, Control surfaces on wing, horizontal and vertical stabilizers, Airfoil and finite wing aerodynamics- a comparison, · Delta wing, high angle of attack aerodynamics, Unsteady effects in airfoils and wings- effect of gust, sudden change in angle of attack, Pitch, heave, flapping, leading edge vortex, dynamic stall

Week 6 : Full Potential Equation and its application, Shock and expansion wave theory, Supersonic flow past a flat plate, Flow through a converging diverging nozzle, Transonic and supersonic flow past airfoil, Shock wave boundary layer interaction, Shock tube, Preliminary concepts of hypersonic flow

Week 7 : Computing aerodynamic flows- main steps and resources, Panel and Vortex Lattice Method, Euler and Navier Stokes equations-I

Week 8 : Euler and Navier Stokes equations-II, What information can be extracted from numerical solutions, Applications of computational aerodynamics- few examples

Week 9 : Wind Tunnel: experimental tool in Aerodynamics, Types of wind tunnels, Wind Tunnel design basics, Similarity analysis, Scaling of wind tunnel models, Safety issues in wind tunnel handling

Week 10 : Flow visualization techniques, Model design and fabrication, Model positioning system, Measurements involving mechanical sensors, Pressure ports, Pitot static tubes, Mechanical balances

Week 11 : Measurements involving electronic transducers, Electronic pressure gages, Strain gage based balances, Data Acquisition System and software, Measurement uncertainty

Week 12 : Velocity measurement using Particle Image Velocimetry, How wind tunnel and associated instrumentation are used for performing aerodynamic studies- few examples, · Quick revision of course content & doubts clarification