CARLETON UNIVERSITY
Department of Mechanical and Aerospace Engineering

LECTURE OUTLINE
AERO 4302 / MECH 5000
Aerodynamics and Heat Transfer / Fundamentals of Fluid Dynamics

Lectures 3 hrs/week
Week

1 Introduction. Governing equations of fluid dynamics – the conservation of mass principle.
2 The principles of conservation of momentum and energy. Subdivision of flows into viscous and inviscid regions.
3 Distortion of fluid elements in flow fields. Circulation. Inviscid flows – the velocity potential function; the stream function. Laplace's equation.
4 Bernoulli's equation for irrotational flows. Simple potential flows: uniform flow; source at origin; vortex at origin.
5 The superposition technique: doublet; source + uniform flow; source + sink+ uniform flow; uniform flow + doublet. The method of images. Vortex motion.
6 Airfoil theory: the Kutta condition; thin airfoil theory.
7 Full velocity potential equation; compressibility correction. Finite-wing aerodynamics.
8 Incompressible viscous flow. Boundary-layer equations. Separation of boundary layers. Integral boundary-layer parameters. The momentum integral equation.
9 Similarity solution of laminar boundary layers. Momentum integral methods and differential methods for laminar boundary-layer calculations.
10 Stability of boundary layers and transition to turbulence.
11 Turbulent boundary layers. Structure of turbulent boundary layers; the law of the wall. Reynolds-averaged Navier-Stokes equations. Boundary-layer equations for turbulent flow. Calculation of turbulent boundary layers.
12 Energy equation of the boundary layer; the thermal boundary layer. Reynolds' analogy.

Learning Outcomes:

- Knowledge of the physical meaning of the terms appearing in the partial differential equations governing fluid motion (Navier Stokes equations)/
- Knowledge of simplified mathematical models of fluid motion (inviscid flow theory; boundary-layer theory).
- Knowledge of the Reynolds averaging technique for modeling turbulent flows.
- Knowledge of the convection heat transfer mode and related mathematical models.
- Knowledge of vorticity as a parameter for studying fluid motion.
- Knowledge of airfoil and wing aerodynamics, and ability to apply the foregoing mathematical models to the study of airfoil/wing aerodynamics

Lecture Format: All of the lectures of this course will be held on Brightspace at the formally scheduled dates and hours. Big Blue Button (BBB) on Brightspace will be used as the lecture platform. In instances of technical issues with Brightspace/BBB, Zoom will be used. A whiteboard on BBB will be used as the "chalkboard", and students are to take hand-written notes during the lectures as they would in a regular in-class setting. The lectures will not be recorded. Audio or video recording of the lectures is not permitted.

Problems: Students will be assigned problems throughout the term. The solutions will not be collected or graded, but students are strongly encouraged to solve these problems independently, as a learning exercise. The ability to apply the course material to solution of problems will be essential to success in the mid-term and final examinations.

Course grading: For both AERO 4302 and MECH 5000, there will be a 2-hour mid-term examination on Nov. 6th, 2021 (3:00 pm to 5:00 pm), and a 3-hour final examination scheduled by the university during the formal final examination period. The university's e-proctoring system will be in effect during both the mid-term and the final examinations.

Graduate students registered in MECH 5000 will have mid-term and final examination questions that are different from those that will be posed to students registered in AERO 4302. While both AERO 4302 and MECH 5000 students will attend the same lectures, MECH 5000 students are expected to develop graduate-level understanding of the subjects covered in this course.

The mid-term and final examination grades will count towards 25% and 75% of the final grade, respectively. During both the midterm and final examinations, students are to develop their answers independently, use a standard calculator, and access only their copy of the required text book of the course, lecture notes, and any material posted on the course's Brightspace page.
.

Required Text:

- Fundamentals of Aerodynamics, Publisher: McGraw-Hill, Author: J.D. Anderson

Additional Recommended Texts:

- Foundations of Aerodynamics, Publisher: Wiley & Sons, Authors: A.M. Kuethe, C-Y. Chow
- Aerodynamics for Engineering Students, Publisher: Butterworth Hinemann, Authors: E.L. Houghton, P.W. Carpenter
- Aerodynamics for Engineers, Publisher: Pearson, Author: J.J. Bertin

M.I. Yaras, September 2021

Academic Accommodation
You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

Pregnancy obligation or Religious obligation: write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website: http://carleton.ca/equity/accommodation/student_guide.htm

Students with disabilities requiring academic accommodations: in this course must register with the Paul Menton Centre for Students with Disabilities (PMC) for a formal evaluation of disability-related needs. Documented disabilities could include but are not limited to mobility/physical impairments, specific Learning Disabilities (LD), psychiatric/psychological disabilities, sensory disabilities, Attention Deficit Hyperactivity Disorder (ADHD), and chronic medical conditions. Registered PMC students are required to contact the PMC, 613-520-6608, every term to ensure that I receive your *Letter of Accommodation*, no later than two weeks before the first assignment is due or the first in-class test/midterm requiring accommodations. If you only require accommodations for your formally scheduled exam(s) in this course, please submit your request for accommodations to PMC by the last official day to withdraw from classes in each term. For more details visit the PMC website:
http://www.carleton.ca/pmc/students/acad_accom.html