

**Department of Mechanical and Aerospace Engineering
CARLETON UNIVERSITY**

**MECH 4305 - Fluid Machinery
COURSE INFORMATION - FALL 2021**

Lectures: **Tuesdays 13:05 - 14:25 Ottawa Time**
 Thursdays 13:05 - 14:25 Ottawa Time

Lectures will be presented **synchronously** on-line at the scheduled times. Login details will be posted on the course website Brightspace ahead of the first lecture. At present, the plan

First Lecture: **Thursday, September 9th, 2021**

Lecturer: **Prof. S.A. Sjolander**
Email: steen.sjolander@cunet.carleton.ca

Office Hours: One hour per week.
 Timing will be discussed during first lecture.

Course Materials: (i) Slides used in lectures will be posted on course website before each lecture.
 (ii) A set of Supplementary Course Notes will be distributed in sections during the term.

LECTURE OUTLINE

Week

- 1,2 Introduction. Types of turbomachines. Dimensional analysis and similarity: application to incompressible and compressible flow machines.
- 3 Operating points. Selection of turbomachine type and size: specific speed and specific size. Cavitation: net positive suction head, suction specific speed, Thoma cavitation parameter.
- 4,5 Energy transfer between fluid and rotor: steady flow energy equation. Angular momentum equation. Euler pump and turbine equation. Degree of reaction; velocity triangles. Stage design parameters: work and flow coefficient.
- 6 **Axial-flow compressors, fans and pumps:** description; advantages and disadvantages; analysis and design considerations. Cascade methods: Howell's correlations; North American practice.
- 7 Blade-element methods. Loss mechanisms. Off-design performance: surge and stall. Multi-stage axial-flow compressors: stage stacking.
- 8,9 **Axial-flow turbines:** description. Stage characteristics. Design and analysis: cascade methods.
- 10 **Centrifugal compressors, fans and pumps:** description; advantages and disadvantages; analysis and design considerations. Head-capacity relations.
- 11 Slip and losses. Surge. Diffuser and volute design considerations.
- 12 Turbomachinery design for gas turbine engines: stages of the design process; analytical tools. Current design issues.

Recommended Texts

All theory and background needed for the course will be presented in lectures and summarized in the Supplementary Course Notes. However, the following two text books may also be found useful:

S.L. Dixon, and C.A. Hall, *Fluid Mechanics, Thermodynamics of Turbomachinery*, 7th ed., Butterworth-Heinemann, 2013.

Covers all the major topics, but sometimes a little briefly. Somewhat short on design information and data, but clearly written.

H.I.H. Saravanamuttoo, G.F.C.Rogers, H. Cohen, P.V. Straznicky, and A.C. Nix, *Gas Turbine Theory*, 7th ed., Pearson Education, London, 2017.

About gas turbine engines generally, but there are useful chapters on the four types of turbomachines which are used most in these engines: axial and centrifugal compressors and axial and radial turbines. These chapters contain methods and correlations which can be used in preliminary aerodynamic design. Also includes a substantial chapter on mechanical design considerations.

Problem Sets

Several problem sets will be distributed during the course. These are not to be handed in and will not be marked, but students are strongly urged to solve these problems independently as a learning exercise. Numerical answers will be provided for most problems and solutions to selected problems will be posted sometime after the problem set has been distributed.

Tentative Course Grading:

Term Work	40%
Final Examination	60%

N.B. The weighting may be adjusted slightly when the overall course grade is finalized.

The **Term Work** will be a 1.5 hr written midterm examination. The examination will be held in the scheduled lecture time slot, most likely in the week after the Study Break.

The **Final Examination** will be a 3.0 hr written examination.

Academic Accommodations:

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

Pregnancy Obligations: Please contact your instructor 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:

<https://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf>

Religious Obligations: Please contact your instructor 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.

Academic Accommodations for Students with Disabilities: If you have a documented disability requiring academic accommodations in this course, please contact the Paul Menton Centre for Students with Disabilities (PMC) at 613-520-6608 or pmc@carleton.ca for a formal evaluation or contact your PMC coordinator to send your instructor your Letter of Accommodation at the beginning of the term. You must also contact the PMC no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with your instructor as soon as possible to ensure accommodation arrangements are made. For more details, visit the Paul Menton Centre website.

Survivors of Sexual Violence: As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: carleton.ca/sexual-violence-support.

Accommodation for Student Activities: Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact your instructor 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, see the policy at: <https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf>

S.A. Sjolander
August 2021