MAE 600: Fluid Flow Control (3 Credits Hours)
Fall 2021

Instructor
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Course Information

	Time (EST)	Location
Classes	Monday/Wednesday/Friday 11:40 AM - 12:35 PM	Link Hall 105
Office hours	By appointment	Link Hall 212

Course Description

Introduction of state-of-art flow control techniques; passive and active flow control; modal/non-modal and data-driven analysis; dynamical system for fluid flow; open-loop and closed-loop control designs.

Prerequisite Courses (desired but not requested)

- MAE 341: Fluid Mechanics
- MAE 643: Fluid Dynamics

Audience

Graduate students & Senior Mechanical and Aerospace Engineering undergraduate students with permission

Textbooks

- J. Wang and L. Feng, *Flow Control Techniques and Applications*, Cambridge Aerospace Series, Cambridge University Press.
- R. D. Joslin and D. N. Miller, *Fundamentals and Applications of Modern Flow Control*, AIAA.
- M. Gad-el-Hak, *Flow Control - Passive, Active and Reactive Flow management*, Cambridge University Press.

Course Learning Objectives

At the completion of the course, each student should be capable of identifying primary fluid flow features and design flow control strategies from various perspectives.

Course Requirements and Expectations

Two projects with topic of flow control techniques will be assigned in this course.

1. **The first project** requests students to perform **literature review** for the topic they select and give a presentation as mid-term project.
2. **The second project** requests students to perform simulations or experiments to **demonstrate the control authority** of the selected control topic in project one.

Grading

- The final grade will be computed using:

Mid-term project presentation	30%
Final-term project presentation	30%
Final project report	40%

- Numeric scores will be translated into letter grades with the following table:

		100-94	A	93-90	A-
89-87	B+	86-84	B	83-80	B-
79-77	C+	76-74	C	73-70	C-
69-60	D	< 60	F		

- Course Evaluations - Students will be asked to fill in an on-line evaluation form covering the course content and instructor effectiveness in conveying course objectives. This feedback will be used to improve the course in the future.

Course Schedule

Week/Lecture	**Topic**	**Reading and Assignment**
Week 1 (8/30)	Fluid flow control introduction	J. Wang and L. Feng
Week 2 (9/6)	Passive/active control techniques (1) - Gurney Flap/Vortex Generator/Roughness	
Week 3 (9/13)	Passive/active control techniques (2) - Biological Techniques	
Week 4 (9/20)	Passive/active control techniques (3) - Jet/Plasma	
Week 5 (9/27)	Separation control (1)	R. D. Joslin and D. N. Miller
Week 6 (10/4)	Separation control (2)	
Week 7 (10/11)	CFD Application Demo course & Mid-term presentation	
Week 8 (10/18)	Role of instability theory in flow control	
Week 9 (10/25)	physics-driven flow control design and new perspectives (1)	Publications
Week 10 (11/1)	physics-driven flow control design and new perspectives (2)	
Week 11 (11/8)	physics-driven flow control design and new perspectives (3)	
Week 12 (11/15)	Dynamic models of fluid system (1)	
Week 13 (11/22)	Dynamic models of fluid system (2)	
Week 14 (11/29)	Closed-loop control	
Week 15 (12/6)	Final project presentation	

University Attendance Policy

Attendance in classes is expected in all courses at Syracuse University. Students are expected to arrive on campus in time to attend the first meeting of all classes for which they are registered. Students who do not attend classes starting with the first scheduled meeting may be academically withdrawn as not making progress toward degree by failure to attend. Instructors set course-specific policies for absences from scheduled class meetings in their syllabi.

It is a federal requirement that students who do not attend or cease to attend a class to be reported at the time of determination by the faculty. Faculty should use "ESPR" and "MSPR" in Orange Success to alert the Office of the Registrar and the Office of Financial Aid. A grade of NA is posted to any student for whom the Never Attended flag is raised in Orange SUccess. More information regarding Orange SUccess can be found at http://orangesuccess.syr.edu/getting-started-2/.

Students should also review the University's religious observance policy and make the required arrangements at the beginning of each semester.

Syracuse University Policies:

Syracuse University has a variety of other policies designed to guarantee that students live and study in a community respectful of their needs and those of fellow students. Some of the most important of these concern:

Diversity and Disability (ensuring that students are aware of their rights and responsibilities in a diverse, inclusive, accessible, bias-free campus community) can be found here, at:
https://www.syracuse.edu/life/accessibilitydiversity/.

Religious Observances Notification and Policy (steps to follow to request accommodations for the observance of religious holidays) can be found here, at: http://supolicies.syr.edu/studs/religious_observance.htm.

Orange SUccess (tools to access a variety of SU resources, including ways to communicate with advisors and faculty members) can be found here, at: http://orangesuccess.syr.edu/getting-started-2/.

Disability-Related Accommodations

Syracuse University values diversity and inclusion; we are committed to a climate of mutual respect and full participation. There may be aspects of the instruction or design of this course that result in barriers to your inclusion and full participation in this course. I invite any student to meet with me to discuss strategies and/or accommodations (academic adjustments) that may be essential to your success and to collaborate with the Center for Disability Resources (CDR) in this process.

If you would like to discuss disability-accommodations or register with CDR, please visit Center for Disability Resources. Please call (315) 443-4498 or email disabilityresources@syr.edu for more detailed information.

CDR is responsible for coordinating disability-related academic accommodations and will work with the student to develop an access plan. Since academic accommodations may require early planning and generally are not provided retroactively, please contact CDR as soon as possible to begin this process.
https://disabilityresources.syr.edu/.

Academic Integrity Policy

Syracuse University's Academic Integrity Policy reflects the high value that we, as a university community, place on honesty in academic work. The policy defines our expectations for academic honesty and holds students accountable for the integrity of all work they submit. Students should understand that it is their responsibility to learn about course-specific expectations, as well as about university-wide academic integrity expectations. The policy governs appropriate citation and use of sources, the integrity of work submitted in exams and assignments, and the veracity of signatures on attendance sheets and other verification of participation in class activities. The policy also prohibits students from submitting the same work in more than one class without

receiving written authorization in advance from both instructors. Under the policy, students found in violation are subject to grade sanctions determined by the course instructor and non- grade sanctions determined by the School or College where the course is offered as described in the Violation and Sanction Classification Rubric. SU students are required to read an online summary of the University's academic integrity expectations and provide an electronic signature agreeing to abide by them twice a year during pre-term check-in on MySlice.

General Guidance for Instructors

Use of Turnitin: (In order to comply with University policies and federal and state law, instructors who plan to use the software program Turnitin, are required to notify students in advance using syllabus language and one of two methods outlined here: https://provost.syr.edu/important-syllabus-reminders/.

Academic work: completed during a semester may be used by professors for educational purposes in courses during the semester. Students' registration and continued enrollment constitute consent for this purpose. Before using students' work for educational purposes in subsequent semesters, professors will either request students' permission in writing and render the work anonymous by removing all personal identification.

ABET PROGRAM OUTCOMES

- **Outcome 1**: An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
  - a. Identify and select appropriate engineering principles and concepts applicable to a given situation.
  - b. Extract Pertinent information from appropriate references
  - c. Solve the problem by correctly using methods (math operations, techniques, and fundamental laws)
- **Outcome 2**: An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
  - a. Translate design requirements into technical criteria, considering factors such as customer needs and multidisciplinary relationships.
  - b. Compare alternative design options considering factors such as performance economics, manufacturability, and safety.
- **Outcome 3**: An ability to communicate effectively with a range of audiences.
  - a. Be able to present technical content accurately.
  - b. Ensure that written content is clear and concise, with appropriate style and format suitable for intended readers.
  - c. Be able to present their work orally and professionally, using diverse approaches.
- **Outcome 4**: An ability to recognize the ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
  - a. Demonstrate an awareness of ethical issues arising in work places and demonstrate readiness to address them using appropriate resources.
  - b. Recognize the significance and consequences of past and present engineering solutions in global, economic, environmental, societal and historical perspectives.
- **Outcome 5**: An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
  - a. Share responsibilities in a team's decision making process
  - b. Be able to adjust to different roles when working in teams (leader, writer, etc.), and learn different points of view when working in teams
- **Outcome 6**: An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions
  - a. Demonstrate an understanding of various measurement techniques
  - b. Ensure that a test procedure corresponds to appropriate analytical needs
  - c. Demonstrate an ability to accurately process, interpret and statistically analyze data cognizant of assumptions and uncertainties
- **Outcome 7**: An ability to acquire and apply new knowledge as needed, using appropriate learning strategies
  - a. Re-learn previously covered materials as necessary
  - b. Learn new materials independently as needed
  - c. Demonstrate an awareness of resources available for continuous learning, such as professional societies, short courses, online learning resources, and advanced degrees

- **Outcome 8**: N/A
- **Outcome 9**: An ability to apply knowledge of aerodynamics, structures, propulsion, flight mechanics and orbital mechanics in the analysis of aerospace vehicles
  - a. An ability to determine the factor of safety of typical aerospace material and structural configurations, such as metallic stiffened-skin wing construction, rocket stages and pressurized fuselage sections, that are subjected to known loadings
  - b. An ability to design a preliminary trajectory and the associated impulse requirements for a specified space mission, such as an International Space Station rendezvous or an Earth-Saturn mission with sunny side swing by Jupiter
  - c. An ability to apply aerodynamic theory to determine the lift and moment coefficients of airfoils and finite wings, as well as to estimate the drag coefficients of wings and fuselages
  - d. An ability to determine aircraft performance, such as take-off, landing, climb and range, and to determine the static and dynamic stability of an airplane
  - e. An ability to analyze typical air-breathing engine systems and component performances for such things as thrust specific fuel consumption and component efficiencies
  - f. An ability to design and compute the performance of a multistage rocket booster by suitable selection of stage characteristics for a specified mission, such as landing a 2000 kg spacecraft on Mars
  - g. An ability to apply shock wave theory to typical aerospace problems such as estimating vehicle wave drag and rocket nozzle performance