FAU

FLORIDA ATLANTIC UNIVERSITY

# NEW COURSE PROPOSAL
## Undergraduate Programs

**Department** Ocean & Mechanical Engineering

**College** COECS

*(To obtain a course number, contact **erudolph@fau.edu**)*

UUPC Approval 4-26-21
UFS Approval _____
SCNS Submittal _____
Confirmed _____
Banner Posted _____
Catalog _____

| | | | |
|---|---|---|---|
| **Prefix** EAS<br>**Number** 4101 | *(L = Lab Course; C = Combined Lecture/Lab; add if appropriate)*<br>**Lab Code** | **Type of Course**<br>Lecture | **Course Title**<br>Aerodynamics |

**Credits** *(Review Provost Memorandum)*: 3

**Effective Date** *(TERM & YEAR)*: Fall 2021

**Grading** *(Select One Option)*: Regular (●) Pass/Fail ( ) Sat/UnSat ( )

**Course Description** *(Syllabus must be attached; Syllabus Checklist recommended; see Guidelines)*

This course will introduce engineering concepts and analytical techniques used in aeronautical engineering. The course will focus on the aerodynamics of airfoils and wings in subsonic, transonic and supersonic flight.

| **Prerequisites,** with minimum grade* | **Corequisites** | **Registration Controls** *(Major, College, Level)* |
|---|---|---|
| EML 3701 Fluid Mechanics | | |

**Default minimum passing grade is D-.* ***Prereqs., Coreqs. & Reg. Controls are enforced for all sections of course***

**WAC/Gordon Rule Course**

( ) Yes (●) No

WAC/Gordon Rule criteria must be indicated in syllabus and approval attached to proposal. See WAC Guidelines.

**Intellectual Foundations Program (General Education) Requirement** *(Select One Option)*

None

General Education criteria must be indicated in the syllabus and approval attached to the proposal. See GE Guidelines.

**Minimum qualifications to teach course**

Ph.D Degree in Mechanical or Aerospace Engineering and equivalent

**Faculty Contact/Email/Phone**

Dr. S. Verma/vermas@fau.edu 954-924-7202

**List/Attach comments from departments affected by new course**

| ***Approved by*** | ***Date*** |
|---|---|
| Department Chair Manuel Cruz | 4-12-21 |
| College Curriculum Chair Daniel Meeroff | 4-15-21 |
| College Dean Fred Bloetscher | 4-15-21 |
| UUPC Chair Jerry Haky | 4-26-21 |
| Undergraduate Studies Dean Edward Pratt | 4-26-21 |
| UFS President | |
| Provost | |

Email this form and syllabus to mjenning@fau.edu seven business days before the UUPC meeting.

**Department of Ocean and Mechanical Engineering, Florida Atlantic University**
**Course Syllabus**

| **1. Course title/number, number of credit hours** | |
|---|---|
| **EAS 4101 Aerodynamics** | 3 credit hours |

**2. Instructional Method**

This class consists of lectures which will be conducted in-class and/or live using WebEx or Zoom, and recorded so students can watch the lectures at a later time and date. Students will be accommodated as much as possible with their needs during the pandemic.

**You will need to have a computer (or laptop), a reliable WIFI access, and a webcam and micro-phone connected to your computer for this course**.

In the event you might not have a computer, there is a Laptop Loaner Program at FAU for first-generation, low-income students.
https://www.fau.edu/newsdesk/articles/fau-announces-laptop-loaner-program.php

In the event you might not have reliable internet access remotely, you may use the internet connection on campus. You may use the classroom during the live course times for watching lectures, and taking quizzes and exams. Note that there are only reduced seating capacities in the classroom, and only those who do not have reliable internet access should use the classroom. Social distancing must be strictly followed in the classroom at all times. You will need to make reservation for your seating every week on Canvas. The instructions for the reservation are provided at the following link:
https://fau.edu/oit/instructional/support/files/seatReservationTool_student.pdf

**3. COVID 19 Statement**

All students in face-to-face classes are required to wear masks during class, and students must sanitize their own workstations upon entering the classroom. Taking these measures supports the safety and protection of the FAU community. Students who do not adhere to these rules will be asked to leave the classroom and/or be removed from the course. Students experiencing flu-like symptoms (fever, cough, shortness of breath), or students who have come in contact with an infected person should immediately contact FAU Student Health Services (561-297-3512).

**4. Course pre-requisites, co-requisites, and where the course fits in the program of study**

**List Prerequisites, Co-requisites**:

Prerequisite: Fluid Mechanics (EML 3701)

If students have not completed the required prerequisites for the course and do not inform their course instructor and advisor, they will be dropped from the course. If this occurs after the first week of the semester, they will be fee liable to the University.

**5. Course logistics**

*Term*: Summer 2021

This is a Fully Online Class with Live Lecture

Class location and time: MW 11:30am - 01:05pm Online via Zoom:

**6. Instructor contact information**

| | |
|---|---|
| *Instructor's name* | Siddhartha Verma |
| *Office address* | Seatech 235 |
| *Office Hours* | Online by Appointment |
| *Contact telephone number* | 954.924.7202 |
| *Email address* | vermas@fau.edu |

**7. TA contact information**

| | |
|---|---|
| *TA's name*<br>*Office address*<br>*Office Hours*<br>*Contact telephone number*<br>*Email address* | |

**8. Course description**

This course will introduce engineering concepts and analytical techniques used in aeronautical engineering. The course will focus on the aerodynamics of airfoils and wings in subsonic, transonic and supersonic flight.

**9. Course objectives/student learning outcomes/program outcomes**

| | |
|---|---|
| *Course objectives* | The objective of the course is to provide the students with a basic introduction to incompressible and compressible aerodynamics. The students will:<br>1. Learn how lift, drag and pitching moment are generated<br>2. Learn airfoil and wing geometric parameters and aerodynamic performance characteristics (Cp, Cl, Cm, Cd, Drag Polar)<br>3. Learn how the Potential Flow approach can be used to predict incompressible and compressible aerodynamics<br>4. Learn the boundary-layer concept for modeling the effects of viscosity |
| *Student learning outcomes & relationship to ABET 1-7 objectives* | Students will be able to:<br>1. Use analytical methods to estimate lift and drag (including viscous effects) on airfoils, wings and bodies of revolution in subsonic and supersonic flight. (1)<br>2. Use numerical methods to calculate aerodynamic loads and moments (including viscous effects) on 2-D and 3-D bodies in in incompressible and compressible flow (Panel methods and integral boundary layer methods) (1)<br>1. Describe physical characteristics (including momentum and thermal) of laminar and turbulent boundary layers, transition and separation. (7) |

**10. Course evaluation method**

| | |
|---|---|
| Homework | 40% |
| Project | 20% |
| Midterm | 20% |
| Final | 30% |

**11. Course grading scale**

| | | | |
|---|---|---|---|
| **A** | **> 95%** | **C+** | **70 – 74.9** |
| **A-** | **90 – 94.9** | **C** | **65 – 69.9** |
| **B+** | **85 – 89.9** | **C-** | **60 – 64.9** |
| **B** | **80 – 84.9** | **D** | **50 – 59.9** |
| **B-** | **75 – 79.9** | **F** | **< 50** |

**Note: The minimum grade required to pass the course is C.**

**12. Policy on makeup tests, late work, and incompletes**

Late work will not be accepted unless there is solid evidence of a medical or otherwise serious emergency that prevented the student from completing the assignments on time. Incomplete grades are against the policy of the department. Unless there is solid evidence of medical or otherwise serious emergency situation, incomplete grades will not be given.

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**13. Special course requirements**

**Special instructions due to hybrid teaching restrictions:**

1. Canvas registration is required.
2. The instructor will regularly post materials/announcements on Canvas. It is student's responsibility to regularly check Canvas and their FAU email for the most recent information.
3. No hard-copy handouts will be provided. Copies will be posted in files on Canvas
4. Attendance is required. All classes will be hybrid, with the live-remote session delivered via WebEx in Canvas. You are expected to participate in all sessions and keep up with the material.
5. Students need a reliable internet condition capable of streaming WebEx lectures, taking exams on Canvas, etc. Recommended: Broadband Internet connection with a speed of 4 Mbps or higher. To function properly, Canvas requires a high-speed Internet connection (cable modem, DSL, satellite broadband, T1, etc.). The minimum Internet connection speed to access Canvas is a consistent 1.5 Mbps (megabits per second) or higher
6. Students should have an operational computer system equipped with Windows 10 or macOS Sierra (or higher), Microsoft Office, web browser, a webcam, speakers, and microphone, which should be compatible with the most recent version of LockDown Browser, Respondus Monitor, Cisco WebEx, etc.
7. All exams will be held using either LockDown Browser and Respondus Monitor, or live via Zoom/WebEx, as determined by the instructor. More information will be provided as we get closer to exams. You must be able to scan answers and upload them to Canvas during tests. Please test this BEFORE the exam.
8. These are the links where you can find the steps to use your cell phone as a webcam.

For Android:
https://helpdesk.fau.edu/TDClient/2061/Portal/KB/ArticleDet?ID=104057

For iPhone or iPad
https://helpdesk.fau.edu/TDClient/2061/Portal/KB/ArticleDet?ID=104056

More details will be announced throughout the semester. It is the students' responsibility to review and follow communications posted by the instructor.

**14. Classroom etiquette policy**

University policy requires that in order to enhance and maintain a productive atmosphere for education, personal communication devices, such as cellular phones, are to be turned off in class sessions.

**15. Attendance Policy Statement**

Students are expected to attend all of their scheduled University classes and to satisfy all academic objectives as outlined by the instructor. The effect of absences upon grades is determined by the instructor, and the University reserves the right to deal at any time with individual cases of non-attendance.

Students are responsible for arranging to make up work missed because of legitimate class absence, such as illness, family emergencies, military obligation, court-imposed legal obligations or participation in University approved activities. Examples of University-approved reasons for absences include participating on an athletic or

scholastic team, musical and theatrical performances and debate activities. It is the student's responsibility to give the instructor notice prior to any anticipated absences and within a reasonable amount of time after an unanticipated absence, ordinarily by the next scheduled class meeting. Instructors must allow each student who is absent for a University-approved reason the opportunity to make up work missed without any reduction in the student's final course grade as a direct result of such absence.

**16. Disability Policy Statement**

In compliance with the Americans with Disabilities Act Amendments Act (ADAAA), students who require reasonable accommodations due to a disability to properly execute coursework must register with Student Accessibility Services (SAS) and follow all SAS procedures. SAS has offices across three of FAU's campuses – Boca Raton, Davie and Jupiter – however disability services are available for students on all campuses. For more information, please visit the SAS website at *www.fau.edu/sas/*

**17. Counseling and Psychological Services Center**

Life as a university student can be challenging physically, mentally and emotionally. Students who find stress negatively affecting their ability to achieve academic or personal goals may wish to consider utilizing FAU's Counseling and Psychological Services (CAPS) Center. CAPS provides FAU students a range of services – individual counseling, support meetings, and psychiatric services, to name a few – offered to help improve and maintain emotional well-being. For more information, go to http://www.fau,edu/counseling/

**18. Code of Academic Integrity Policy Statement**

Students at Florida Atlantic University are expected to maintain the highest ethical standards. Academic dishonesty is considered a serious breach of these ethical standards, because it interferes with the university mission to provide a high quality education in which no student enjoys unfair advantage over any other. Academic dishonesty is also destructive of the university community, which is grounded in a system of mutual trust and place high value on personal integrity and individual responsibility. Harsh penalties are associated with academic dishonesty. See University Regulation 4.001 at
www.fau.edu/regulations/chapter4/4.001_Code_of_Academic_Integrity.pdf

Cell phones are not allowed during exams. If cell phones are detected during any exam periods, this will result in a **grade of "zero" on that exam and a note in the student's academic file.**

**19. Required texts/reading/Lab kits**

John D. Anderson: Fundamentals of Aerodynamics

**20. Supplementary/recommended readings**

John D. Anderson: Introduction to Flight

**21. Course topical outline, including dates for exams/quizzes, papers, completion of reading**

***Topics:***

1. Fluid Motion Basics: Streamlines, pathlines, steady vs. unsteady, vorticity, boundary layer
2. Incompressible Viscous Flow
    a. Simple solutions to the Navier-Stokes equations, boundary layer equations: exact solutions, Blasius solution, pressure gradient effects
    b. Physics of turbulence and its effects, turbulent flat plate solutions, factors affecting transition
    c. Momentum Integral Method, Thwaites Method, Head's Method, Squire-Young formula for drag, empirical methods for transition estimate, Michel's Criteria
3. Compressible Viscous Flow: Compressibility corrections to boundary layer equations, prediction of skin friction and heat transfer
4. Potential Flow: Derivation of Velocity Potential Equations for Compressible and Incompressible Flows
5. Low Speed Aerodynamics
    a. Elementary solutions for incompressible Potential Flow: uniform flow, source/sink, doublet, vortex
    b. Flow around 2-D cylinder, concept of circulation, Kutta-Joukowsky Theorem, drag in separated flow, Cp distribution
    c. Airfoils
    d. Thin Airfoil Theory, Kutta Condition, Cl, Cm, lift curve slope, center of pressure, aerodynamic center
    e. Overview of panel methods, numerical tools for prediction of skin friction drag around airfoils
6. Wings
    a. Physical characteristics, trailing vortices, vortex sheet, starting vortex, downwash, induced drag, effect of aspect ratio
    b. Prandtl's lifting line theory and numerical tools
    c. Induced drag, elliptical lift distribution, span efficiency factor, drag polars including viscous effects,
    d. Vortex dominated flows and leading edge vortices
7. High Speed Aerodynamics: Normal and oblique shock waves, nozzles and wind tunnels, methods of analyzing compressible flow about airfoils, wings, and bodies.
8. Derivation of Linearized Potential Flow Equation, small disturbance approximations
    a. Subsonic Flow over Airfoils: Prandtl-Glauert Rule, compressibility corrections and effects on lift, drag and Cp distribution
    b. Subsonic Flow over Wings and Bodies: Modifications to lifting line analysis to include compressibility effects, Potential Flow over Body of Revolution using Gothert's Rule, closed form expressions for Cp and Cd, Sources of drag
    c. Transonic Effects on Airfoils, Wings and Bodies of Revolution: Transonic flow effects on Cl, Cd, Cm and Cp, finding Critical Mach Number of airfoils and bodies of revolution, Wave drag, Drag divergence; elimination of drag rise by sweep, area rule, supercritical airfoils.
    d. Supersonic and Hypersonic Flow Prediction: Sources of drag, Determination of lift and drag using linearized supersonic flow, shock-expansion wave theory, Newtonian Theory, Modified Newtonian Theory