Course Change Request

Date Submitted: 02/23/18 8:46 am

Viewing: **AERO 351 : Aerothermodynamics and Propulsion**

Last approved: 02/23/18 3:28 am
Last edit: 02/27/18 8:20 am
Changes proposed by: escamc

<table>
<thead>
<tr>
<th>Catalog Pages referencing this course</th>
</tr>
</thead>
<tbody>
<tr>
<td>AERO - Aerospace Engineering (AERO)</td>
</tr>
<tr>
<td>Department of Aerospace Engineering</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other Courses referencing this course</th>
</tr>
</thead>
<tbody>
<tr>
<td>As A Banner Prerequisite:</td>
</tr>
<tr>
<td>AERO 401 - Aerospace Vehicle Design</td>
</tr>
<tr>
<td>AERO 417 - Aerospace Propulsion</td>
</tr>
<tr>
<td>AFRO 419 - Chemical Rocket Propulsion</td>
</tr>
</tbody>
</table>

Faculty Senate Number: 68.25.113

Contact(s)

<table>
<thead>
<tr>
<th>Name</th>
<th>E-mail</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Christina Escamilla</td>
<td><a href="mailto:escamc@tamu.edu">escamc@tamu.edu</a></td>
<td>9798452685</td>
</tr>
</tbody>
</table>

Rationale for Course

Edit

The proposed changes are to meet the demand/interest of students.

Course prefix: AERO  Course number: 351

Department: Aerospace Engineering
College/School: College of Engineering
Academic Level: Undergraduate

Undergraduate course level justification (Select One)

Academic Level (alternate): Graduate

Effective term: 2018-2019

Complete Course Title: Aerothermodynamics and Propulsion

Abbreviated Course Title: AERO Thermo PROPULSION

Catalog course description:

Aerothermodynamics of gases; laws of thermodynamics; equilibrium conditions; mixtures of gases; combustion and thermochemistry; compressible internal flows with friction, heat transfer and shock; turbojet cycle analysis and performance; chemical rockets.

Prerequisites and Restrictions

Grade of C or better in AERO 303 or concurrent enrollment.

Concurrent Enrollment: No

Should catalog prerequisites / concurrent enrollment be enforced? Yes
Enforced Prerequisites / Concurrent Enrollment

<table>
<thead>
<tr>
<th>And/Or</th>
<th>Course Prefix/Number</th>
<th>Min Grade/Score</th>
<th>Academic Level</th>
<th>Concurrency?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AERO 303</td>
<td>C</td>
<td>UG</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Crosslistings: No  
Crosslisted With:  
Stacked: No  
Stacked with:  

Semester: 3  
Credit Hour(s):  
Repeatability: No  
Repeatable for credit: No  
Three-peat?: No  
GIP/Fund Code: 1402010006  
Default Grade Mode: Letter Grade(G)  
Alternate Grade Modes: Satisfactory/Unsatisfactory  
Method of instruction: Lecture  
Will sections of this course be taught as non-traditional? (i.e., parts of term, distance education): Yes

Learning Outcomes

- Meets traditional face-to-face learning outcomes.

Describe how learning outcomes are met or provide justification why they are not met.

- Meets traditional face-to-face learning outcomes

Hours

- Meets traditional face-to-face hours.

Describe how hours are met or provide justification why they are not met.

- Meets traditional face-to-face hours

Will this course be taught as a distance education course?  
No

Is 100% of this course going to be taught in Texas?  
No Yes

Will classroom space be needed for this course?  
Yes

This will be a required course or an elective course for the following programs:

<table>
<thead>
<tr>
<th>Required (select program)</th>
<th>Program(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(BS-AERO) Aerospace Engineering - BS</td>
<td></td>
</tr>
</tbody>
</table>
Course Syllabus

Syllabus: Upload syllabus
Upload syllabus
AERO 351 Brazil.pdf
AERO 351.pdf

Letters of support or other documentation: Yes

Additional information
Reviewer Comments: Sandra Williams (sandra-williams) [03/09/18 3:28 pm]: UCC approved March 9 via e-vote.

Reported to state: No
Aerothermodynamics and Propulsion (AERO 351)

Course Syllabus - Spring 2018

INSTRUCTOR: Paul Cizmas, Professor of Aerospace Engineering
631B Bright Building
Phone: 845-5952
E-mail: cizmas@tamu.edu

TEXTBOOK: Class notes, http://dayton.tamu.edu/aero351.htm

ADDITIONAL REFERENCES:

COURSE OBJECTIVES: Review and enhance the fluid mechanics and thermodynamics knowledge necessary for understanding jet propulsion. Describe jet engine and rocket engine components. Present jet engine components analysis, and jet engine performance analysis.

PREREQUISITES: AERO 301

ATTENDANCE POLICY: Students are expected to attend class.

COURSE DESCRIPTION: Aerothermodynamics of gases; laws of thermodynamics; equilibrium conditions; mixtures of gases; combustion and thermochemistry; compressible internal flows with friction, heat transfer and shock waves; turbojet cycle analysis and performance; chemical rockets.

LEARNING OBJECTIVES: At the end of this course, students will be able to:

1. Explain the fundamental principles of aerospace propulsion including classical thermodynamics, compressible flow, viscous flow, heat transfer, combustion chemistry, and cycle analyses.

2. Analyze air breathing engine system/component performance.

3. Analyze rockets engine system/component performance.

4. Explain the functioning of advanced propulsion systems (e.g., scramjets, combined cycle propulsion, turbine combustors).

COURSE CONTENT:

Lab Safety 0.5 hours

I. Basic Fluid Mechanics and Thermodynamics for Propulsion

A. Introduction. Jet Propulsion Principle 1.5 hours
B. Aerothermodynamics review: Fundamental equations 6 hours
C. Steady One-Dimensional Gas Dynamics Compressible flows. Shock waves 4 hours
D. Boundary layer. Thermal boundary layer 3 hours
II. Air Breathing Engines

A. Introduction to air breathing engines. Thrust equation. 2 hours
B. Engine performance. 1 hour
C. Brayton cycle. Ideal and real cycle (air). 2 hours
D. Introduction to combustion. 1 hour
E. Thermodynamics of chemistry: enthalpy of formation, reaction and combustion. 2 hours
F. Turbojet real cycle with actual medium. 2 hours
G. Turbofan real cycle with actual medium. 2 hours
H. Thrust increase: afterburning and water injection. 2 hours
I. Turboprop and turboshift real cycle with actual medium. 2 hours
J. Compressors. 3 hours
K. Turbines. 3 hours

III. Rocket Engines

A. Rocket engines. Performance of rocket vehicles. 1 hour
B. Chemical rockets. 2 hours
C. Electrical rockets. 2 hours

TOTAL 42 hours

GRADE EVALUATION:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>5%</td>
</tr>
<tr>
<td>Quizzes and projects</td>
<td>15%</td>
</tr>
<tr>
<td>Exam 1, Feb. 21, 5:00-8:00 pm, RICH 106</td>
<td>25%</td>
</tr>
<tr>
<td>Exam 2, Mar. 28, 6:00-8:00 pm, RICH 106</td>
<td>25%</td>
</tr>
<tr>
<td>Final Exam (comprehensive), May 3, 10:00-12:00</td>
<td>30%</td>
</tr>
</tbody>
</table>

Grading policy: Standard TAMU grading system, that is,

A $\geqslant$ 90%, 80% $\leqslant$ B $\leqslant$ 89%, 70% $\leqslant$ C $\leqslant$ 79%, 60% $\leqslant$ D $\leqslant$ 69%, F $\leqslant$ 59%

Note 1: The homework is extremely important. The goal of the homework is to reinforce what you have learned and to try to make it obvious what is not clear. There will be approximately one homework per week. The homework solutions will be on the fileservers before the homework is due (with very rare exception), so grading will be done much differently than you have seen in previous courses. You will hand in two documents for each homework assignment. Each document is worth 50% of the homework grade. Note that you can guarantee a 100% average on the homework by completing the following.

The first document is your homework solutions. Your work will not be graded except that if you do not complete a problem, you will get a zero for that problem. Since you will have solutions, you can get full credit by copying the solution posted. If you simply copy a solution, you will definitely be answering part C in the second document for this problem. If you find yourself simply copying solutions with any regularity, you need to see me immediately.

The second document will provide answers to the following for each problem.

[A] Were you able to understand and work this problem correctly without using the solution provided?

[B] If the answer to question A is "no", were you able to understand and work this problem correctly after studying the solution provided?

[C] If the answer to question B is "no", indicate what part(s) of the solution are unclear. In some cases, you might understand the individual steps, but not the overall strategy or how to get started. Indicate if that is the case. Understanding why particular steps are taken is just as important as the steps themselves. If it is difficult to explain what is not clear about the solution, print out the solution, mark what is not clear, and include the copy with your submission.
Warning: Do not be tempted to answer "yes" to A or B just to save time. If you answer A or B, you are saying that you are ready to be tested on the material.

It is your responsibility to be clear about what you need. It is my responsibility to try to meet that need either by addressing it in class or in my office. I can answer simple questions via e-mail, but a face-to-face meeting in class or in my office is needed for other than the simple questions. If you are not satisfied with my explanations, it is your responsibility to speak up.

Note 2: Students are encouraged to discuss with each other how to approach the homework problems but each student must re-think and privately prepare his/her final solution to each problem. The homework solutions submitted must represent your work that you have carefully thought through and you must be prepared to explain each answer in detail.

Note 3: Complaints about grades must be made within two weeks of when the material is returned to the class. Beyond that time, the grade will not be changed.

Note 4: Makeup exams must take place during the approved academic calendar period and no later than one week from the date of the original exam.

OFFICE HOURS: I do not have any set office hours. Come by when it is convenient for you. However, I may request you to come back at another time if I am busy. To avoid this, you can e-mail ahead and set up a time to meet.

NOTICE Required by the Federal Government: "The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring accommodation, please contact Disability Services, currently located in the Disability Services building at the Student Services at White Creek complex on west campus or call 845-1637. For additional information, visit http://disability.tamu.edu."

ACADEMIC INTEGRITY: "An Aggie does not lie, cheat or steal, or tolerate those who do." (see http://www.tamu.edu/aggiehonor)

CONTRIBUTIONS TO PROFESSIONAL COMPONENT:

1. First required course in propulsion. Prepares students for senior level design electives and capstone design course.
2. Builds on the foundation established in the core subjects.
3. Part of the required engineering topics portion of the curriculum. Helps prepare students for engineering practice.
4. Prepares the basic foundation for propulsion.
### RELATIONSHIP TO PROGRAM OUTCOMES:

<table>
<thead>
<tr>
<th>Objective</th>
<th>Assessment Method</th>
<th>ABET Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Have knowledge of the evolution of propulsion systems. Understand the jet propulsion principle.</td>
<td>Major Exams and Final Exam</td>
<td>3a, 3f, 3h</td>
</tr>
<tr>
<td>2. Understand the derivation of the conservation equations using the Reynolds Transport Theorem.</td>
<td>Major Exams and Quizzes</td>
<td>3i, 3j</td>
</tr>
<tr>
<td>3. Apply the mass, linear momentum, angular momentum and energy conservation equations to various parts of the propulsion systems.</td>
<td>Major Exams, Final Exam, Homework</td>
<td>3a</td>
</tr>
<tr>
<td>4. Understand how to apply the laws of thermodynamics to propulsion systems.</td>
<td>Major Exams, Final Exam, Homework, Major Exams</td>
<td>3a</td>
</tr>
<tr>
<td>5. Apply the conservation equations to steady, one-dimensional, compressible flows with shock waves.</td>
<td>Homework, Major Exams, Quizzes</td>
<td>3a, 3c</td>
</tr>
<tr>
<td>6. Understand the nozzle operation under varying pressure ratio. Understand the Laval nozzle operation.</td>
<td>Homework, Mini-project</td>
<td>3a</td>
</tr>
<tr>
<td>7. Determine flow parameter variation in inlet nozzles and airfoil cascades due to normal and/or oblique shock waves.</td>
<td>Major Exams and Quizzes</td>
<td>3a</td>
</tr>
<tr>
<td>8. Understand the derivation of the thrust equation for turbojet, turbofan and turboprop engines.</td>
<td>Major Exams and Final Exam</td>
<td>3a</td>
</tr>
<tr>
<td>9. Understand the parameters that define the jet engine performance.</td>
<td>Homework and Mini-project</td>
<td>3a, 3c</td>
</tr>
<tr>
<td>10. Understand Brayton cycle and the differences between Brayton cycle and Carnot cycle.</td>
<td>Major Exams and Homework</td>
<td>3a</td>
</tr>
<tr>
<td>11. Predict jet engine performance using the ideal cycle with air standard, with either constant or variable properties. Predict turbojet engine performance at takeoff and in flight using the real cycle with air standard.</td>
<td>Homework and Mini-project</td>
<td>3a, 3b, 3c</td>
</tr>
<tr>
<td>12. Understand the physical meaning of enthalpy of formation, enthalpy of reaction, higher and lower heating values. Predict the constant-pressure adiabatic flame temperature.</td>
<td>Major Exams and Final Exam</td>
<td>3a, 3d, 3e, 3g, 3k</td>
</tr>
<tr>
<td>13. Predict turbojet, turbofan and turboprop real cycles with actual medium. Compare predicted results against data from the turbojet engine cell.</td>
<td>Homework and Mini-project</td>
<td>3a</td>
</tr>
<tr>
<td>14. Understand the thrust augmentation methodologies using water injection, afterburning or in situ reheat.</td>
<td>Major Exams and Final Exam</td>
<td>3a, 3b, 3c</td>
</tr>
<tr>
<td>15. Understand the compression mechanism in axial and centrifugal compressors. Predict pressure ratio and efficiency of a compressor using the compressor map. Predict compressor pressure ratio using the velocity triangles. Design one-stage compressor.</td>
<td>Homework, Mini-project, Final Exam and Quizzes</td>
<td>3d</td>
</tr>
<tr>
<td>16. Understand the energy transfer in an axial turbine. Predict energy transfer using velocity triangles.</td>
<td>Homework and Final Exam</td>
<td>3a, 3c</td>
</tr>
<tr>
<td>17. Understand the classification of rocket engines. Predict the performance of chemical rocket engines.</td>
<td>Final Exam</td>
<td>3a</td>
</tr>
</tbody>
</table>
Aerospace Engineering 351 Aerothermodynamics and Propulsion
Credit 3: (3-0)
Aerospace Study Abroad in Brasil 2018

Instructor: Adonios Karpetis, Associate Prof, Aerospace Engineering, HRBB 607C, phone 458-4301, email karpetis@tamu.edu


Prerequisites: AERO 212, 301, 303 (or registration therein), MATH 308
Attendance Policy: Students are expected to attend class.

Course Objectives: Review and enhance the fluid mechanics and thermodynamics knowledge necessary for understanding jet propulsion. Describe jet engine and rocket engine components. Present jet engine components analysis, and jet engine performance analysis

Course Description: Aerothermodynamics of gases; laws of thermodynamics; equilibrium conditions; mixtures of gases; combustion and thermochemistry; compressible internal flows with friction, heat transfer and shock; turbojet cycle analysis and performance; chemical rockets.

Learning Objectives: At the end of this course, students will be able to:
1. Explain the fundamental principles of aerospace propulsion including classical thermodynamics, compressible flow, viscous flow, heat transfer, combustion chemistry, and cycle analyses.
2. Analyze air-breathing engine system/component performance
3. Analyze rockets engine system/component performance
4. Explain the functioning of advanced propulsion systems

Topics
I. Basic Foundations; Thermodynamics review
II. Quasi-one-dimensional compressible gas dynamics
III. Thrust equation
IV. Air-breathing engine performance
V. Ideal & real Brayton cycle (air)
VI. Thermodynamics of chemistry, enthalpy of formation, reaction & combustion
VII. Turbojet, turbofans, turboprop, turboshift
VIII. Turbomachinery (compressors & turbines)
IX. Nozzles & afterburners
X. Rockets

Method of Evaluation: Grade curve based on 90/80/65/50% (A/B/C/D)

<table>
<thead>
<tr>
<th>Homework</th>
<th>25% approximately twice weekly, completion grade, class participation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project presentation</td>
<td>25% teams of four students</td>
</tr>
<tr>
<td>Exams</td>
<td>50% two exams</td>
</tr>
</tbody>
</table>
Contributions to Professional Component:
1. First required course in aerospace vehicle propulsion. Prepares students for subsequent senior level design electives and capstone design course.
2. Builds on foundation established in core subjects, and extends knowledge of thermodynamics
3. Part of the required topics of the engineering curriculum. Helps prepare students for engineering practice.
4. Gives students a working knowledge of aerospace vehicle propulsion.

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Assessment Method</th>
<th>ABET Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understand the fundamental thrust equation &amp; principles of propulsion</td>
<td>Homework, class participation, exams</td>
<td>3(a), 3(e), 3(k), Aerodynamics AIAA Program Criteria</td>
</tr>
<tr>
<td>Understand quasi-one-dimensional internal compressible gas flow, and how it relates to nozzle flow</td>
<td>Homework, class participation, exams</td>
<td>3(a), 3(e), 3(k), Aerodynamics AIAA Program Criteria</td>
</tr>
<tr>
<td>Understand the thermodynamics &amp; fluid mechanics of air-breathing engines, performance of compressors &amp; turbines</td>
<td>Homework, team projects, exams</td>
<td>3(a-b), 3(e), 3(k), Aerodynamics AIAA Program Criteria</td>
</tr>
<tr>
<td>Understand rocket propulsion</td>
<td>Homework, team projects, class participation</td>
<td>3(a-e), 3(g), 3(k), Aerodynamics AIAA Program Criteria</td>
</tr>
<tr>
<td>Apply thermodynamics &amp; gas dynamics to assess the performance of aircraft &amp; spacecraft engines &amp; their components as well as the applicability of their models</td>
<td>Homework, team projects, class participation</td>
<td>3(a-g), 3(k), Aerodynamics AIAA Program Criteria</td>
</tr>
</tbody>
</table>

**Americans with Disabilities Act (ADA) Policy Statement**
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