Boston University, ENG ME 425

Compressible flow and propulsion

SYLLABUS FOR Fall 2008

Texts: *Modern Compressible Flow* 3rd ed., J. Anderson Jr.

Fundamentals of Jet Propulsion with Applications R. D. Flack

Revisit this page for updates!

Date	Reading	Topic	Assignment	Due Date
9/3	Chap. 1 (JA)	Introduction	Homework 1	9/8
9/8,10	Chaps. 2&6 (JA)	Governing equations of fluid motion	Homework 2	9/15
9/15	Secs. 3.1-3.5 (JA)	1-D flow, definitions, Normal shocks		
9/17	Secs. 3.6-3.9 (JA)	Normal shocks		
9/17		1-D with heat and friction	Homework 3	9/24
9/22	Chap. 4 (JA)	Oblique shocks (Cone flow? Chap10)		
9/24		Expansion waves	Homework 4	10/1
9/29		MATLAB – project kick-off	Computer project I	
10/1	(RD)	Supersonic inlets		
10/6,8,14	Chap. 5	More quasi-1-D flows, nozzles, diffusers		
10/22,27		Rockets		
		MIDTERM 10/20		
10/29,11/3	(JA+notes)	Transonic flows, Numerical Methods	Computational Lab	

11/5,10,12,17,19	(RD)	Ideal cycle analysis air-breathing	Computer project II	
11/24,12/1	(RD)	Non-ideal cycle		
12/3,8	(RD)	Off design air-breathing		
		Final Dec 17 12:30-2:30		

Boston University - College of Engineering
Course Requisition Form - Summary Page/Data Sheet

Directions: Type normally in the grayed areas, then tab to next area. Type X in the check boxes, then tab to next area.

Date Submitted: 4/1/08

Course Number and Name: ME405 (new number needed) Compressible flow and propulsion

First semester to be offered:	☒ Fall	☐ Spring	☐ Summer 20 08	
Last semester to be offered:	☐ Fall	☐ Spring	☐ Summer 20	☐ offer indefinitely
Course to be scheduled	☒ Automatically		☐ On demand (by department request only)	
Course to be offered :	☒ Fall	☐ Spring	☐ Summer (check *all* that apply)	

Course Designation (check *one)*

- ☒ Lecture
- ☐ Lecture/Lab (course does not require separate lab registration)
- ☐ Lec/Disc (course does not require separate discussion registration)
- ☐ Lecture with separate discussion registration
- ☐ Lecture with separate lab registration
- ☐ Lab with no lecture
- ☐ Independent Study

Lecture hrs/wk: 4
Discussion hrs/wk: 0
Laboratory hrs/wk: 0
Semester credits : 4

Prerequisites: EK303, EK304

Courses for which this course is a prerequisite: none

Is this course a number change only? ☐ Y ☒ N

Additional supplies or resources: none

Authorization for Supplies

Department Chair: _____ Date: _____

This course satisfies the following degree requirements: required for Aero degree, required for ME with Aero concentration

Required ☒
Elective ☐

Course Number and Name: 423/405 Compressible flow and propulsion
Semester and Academic Year:

Proposed Catalog Copy:
Fluid mechanics and and thermodynamics of compressible fluid flow with application to external and internal flows as found in propulsion systems. Fluid/thermal related topics include: normal and oblique shocks, Prandtl-Meyer expansion waves, variable area duct flow, and wave drag. Propulsion applications include: rocket nozzles, rocket engine staging, supersonic inlets and exhaust nozzles for airbreathing propulsion systems. Parametric cycle analysis for ramjet, turbojet, turbofan, and turboprop engines.

Course Schedule (number of hours per week, lecture, lab, discussion):
4 cr, (4 hours per week lecture)

Textbooks (type textbook bio):
Textbook: J. Anderson, Modern Compressible Flow, 3rd Ed. McGraw-Hill, 2003.
Ronald D. Flack, Fundamentals of Jet Propulsion with Applications – Cambridge University Press

Reference (reference bio):
A. M. Kuethe and C.-Y. Chow, Foundations of Aerodynamics, 4th Ed. McGraw-Hill, 1986
Mattingly, Elements of Gas Turbine Propulsion
Hill and Peterson, Mechanics and Thermodynamics of Propulsion - 2nd Ed. , Addison Wesley
Archer and Saarlas, An Introduction to Aerospace Propulsion – Prentice Hall
Sutton and Biblarz, Rocket Propulsion Elements, 7th ed. – Wiley (and other older editions by Sutton)

Coordinator (name, title, department):
Sheryl Grace, Assoc. Prof., ME

Prerequisites by topic:
Intro to fluid mechanics, intro to thermodynamics

Goals (course goals):

This course is designed to provide the senior students majoring or taking a concentration in Aerospace Engineering with a thorough understanding of the fundamental theory of compressible flow with application to the principles of jet and rocket propulsion. In addition, the course will introduce the students to thermodynamic cycle analysis appropriate for airbreathing propulsion systems.

Course Outcomes:

As an outcome of completing this course, students will:

i. Develop the ability to model and study compressible fluid flow systems utilizing natural laws and methods of analysis which include vector field theory and partial differential equations, including application to practical problems. (A, E, AE:M,N)

ii. Become proficient in the application of fundamental thermodynamics and fluid mechanics to the analysis of propulsion systems and their components including: airbreathing engines such as ramjets, turbojets, turbofans and turboprops as well as non-airbreathing engines such as solid and liquid fuel rockets. (A, E, AE:M,N)

iii. Gain experience in generating computer solutions to problems related to compressible fluid mechanics and engine performance. (K)

vi. Gain experience in analysis of results and in writing reports in the process of presenting results from computer simulations (iii above). (G,L)

v. Acquire the ability to gain further understanding of compressible fluid through individual study. (I)

NOT included in the chart below are outcomes AE:M: 5 AE:N: 3

Course Outcomes mapped to Program Outcomes:

Program Outcome	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
Course Outcomes	i,ii				i,ii		vi		v		iii
Emphasis (1-5)	5				5		3		3		4

1=not at all; 5=a great deal

Topics in Project Assignments:

1. Definitions, review of continuity and momentum equations (1 week)
2. Thermodynamics review and energy equation (1 weeks)
3. Shock and expansion waves (2.5 weeks)
4. Subsonic and supersonic airfoils (1 weeks)
5. Supersonic inlets (1 week)
6. Variable area duct (1 week)
7. Rocket nozzles (1 week)
8. Rocket engine staging (1 week)
9. Ideal cycle-analysis of air-breathing engines (1 weeks)
10. Non-ideal cycle analysis of air-breathing engines (1.5 weeks)
11. Off-design performance of air-breathing engines (1 week)

Contribution of Course to Meeting the Professional Component:

Engineering topics (0 – 100%): 100
Math & Basic Science (0 – 100%):
General Education (0 – 100%):

Prepared by: Sheryl M Grace **Date:** 3/31/08

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Course Requisition Form - Signature Page

Course Number and Name: ME405

Submitted by (please type or print): Sheryl M Grace

Signature: _____ Date: _____

Recommended by Department (Chair or Assoc Chair):

Signature: _____ Date: _____

Approved College Grad/Undergraduate Committee _____

Signature: _____ Date: _____

Approved at Faculty Meeting on (Date:) _____(required for Undergraduate courses only)

Administrative Approval: _____

Signature: _____ Date: _____

ENG AM425: Compressible flow and propulsion

General Information

Sheryl Grace
Rm. 407, 110 Cummington St.
sgrace@bu.edu
(617) 353 7364

Course time and location: MW 2-4, PHO 202

Office hours: W H 10-11

Textbook:

Textbooks: J. Anderson, *Modern Compressible Flow,* 3rd Ed. McGraw-Hill, 2003.
R. D. Flack, *Fundamentals of Jet Propulsion with Applications* – Cambridge University Press

Reference:

Kuethe and Chow, *Foundations of Aerodynamics*, 4th Ed. McGraw-Hill, 1986
Mattingly, *Elements of Gas Turbine Propulsion*
Hill and Peterson, *Mechanics and Thermodynamics of Propulsion* - 2nd Ed. , Addison Wesley
Archer and Saarlas, *An Introduction to Aerospace Propulsion* – Prentice Hall
Sutton and Biblarz, *Rocket Propulsion Elements*, 7th ed. – Wiley (and other older editions by Sutton)

Lecture requirements:

- attend
- bring calculator
- bring notebook

Other requirements:

keep neat and complete homework, project, laboratory notebooks that may be collected at the end of the course

Grading:

Approximate Grading Scale (The following scale is subject to change.)

Projects	25%
Computational Lab	10%
Homework(+possible quizzes)	5%
Midterm	30%
Final Examination	30%

Remember: THE PROFESSOR DOES NOT GIVE GRADES, THE STUDENTS EARN A GRADE

Exams will be closed book and held in class. The final exam will be comprehensive. You can bring on 8.5" X 11" sheet written on one side with helpful formulae etc. to the first exam and two such sheets to the final exam.

Homework, which will be assigned in class and noted on the course web page is due at the beginning of the designated class period (unless otherwise noted.) All homework will be graded and returned. The top of the first page of the homework should have: your name and the course number. Every page should have the problem number on the top right corner. There should be no frayed edges and multiple pages must be stapled. You should briefly restate the problem (some even make a photo copy and tape the problem statement to the page). Give a sketch if helpful. List the basic assumptions. Give all necessary analysis. If asked to plot something, you must create a computer generated graph with appropriate axis labels and legend. Place a box around the final answer. Correct units should accompany all numerical answers. **Any answer that is not of the correct order of magnitude, with no accompanying explanation, will be given no points, even if the method used to do the problem is correct.** Homework solutions will be accessible after the assignment is due.

Honest policy: Adherence to the Student Academic Code of Conduct is expected. I encourage you to freely discuss the homework amongst one another as you formulate your solutions individually. *Your* written work should represent *your* understanding of the problem.

In practice this means that copying (in whole or in part) another student's homework, exam, computer program, or paper is not permitted. If you choose to discuss your work with a colleague, it should be a discussion in which one teaches another or both work to a mutual understanding. As a counter-example, it is not acceptable to give a friend your homework five minutes before class so that your friend can copy your work. I also consider it unacceptable to copy work from a student who was in the class a previous

year. In your written reports, be careful to correctly use quotation marks for words that did not originate with you. Also, be sure to properly cite all sources you used. As is done in the scientific literature, you should *briefly* acknowledge in writing any significant discussion or interactions you had regarding the work you submit. As a general principle, I do not accept the justification that you were not sure of my intentions. If you feel you may be in an ethical gray area, then you should consult with me *before* acting.

Course outcomes with their weights (this document is not the final document, but the outcomes and weights are correct)

Computer Usage:

- Some homeworks/projects will require the use of MATLAB, and/or EXCEL. The Lab will require MATLAB usage.

Drop date:

October 6, 2008 (no "W" on record).

Withdrawal:

November 10, 2008 (with a "W" on record). *You will receive a final grade (other than "W") if you do not submit the withdrawal form to the registrar office by November 10th*.