AIRCRAFT PROPULSION
ASEN 5063

(Classroom – ECCS 1B28; Tuesdays and Thursdays 3:30 PM to 4:45 PM)

Course Description:

This course is designed to teach the principles and practice of modern aircraft propulsion. It builds on the principles taught in ASEN 4013 (Fundamentals of Aerospace Propulsion). Gas turbine engines, principally turbofans, form an overwhelming fraction of modern aircraft engines. So the focus will be on turbofans, especially for commercial aircraft, although turboprops and military turbofans will also be considered. The emphasis will be more on the current state of aircraft propulsion, how engine selections are made, and what is necessary for success in the highly competitive field of aircraft propulsion. We will start with a review of the current state of aircraft propulsion and a brief history of gas turbine engines. After a brief overview of the Brayton cycle and a review of the principles of gas turbine engines, we will deal with analysis and design of various components: centrifugal and axial compressors, axial and radial flow turbines, inlets and nozzles, and burners. Compressor-turbine matching will be discussed, followed by analysis of off-design performance of gas turbine engines. Finally, environmental aspects of modern gas turbine engines, noise and emissions, will be dealt with.

We will be following an extensive set of notes I have prepared over the years. These notes will be made available on D2L and will be supplemented by material from a recent textbook on *Aircraft Propulsion* by Farokhi, and a monograph on *Jet Propulsion* by Cumpsty, as needed.

Instructor:

Dr. Lakshmi Kantha
Professor
Department of Aerospace Engineering Sciences
Office: ECAE-117, Phone: 303-492-3014
E-mail: kantha@colorado.edu.

Office Hours: Tuesdays 09:00 AM to 11:00 AM (plus lunch hour on any weekday)

Prerequisites: ASEN 4013 Undergraduate Course on Propulsion or Instructor's consent

Grading: Homework (8) – 40%, Quizzes (5) – 10%, Exams (1) – 20%, Final Project – 30%

Course Outline:

1. Introduction to Current State of Aircraft Propulsion
2. Brief Overview of Jet Propulsion
3. Thermodynamic Cycles – Brayton Cycle

4. Engine Selection
5. Brief Overview of Ideal and Real Cycle Analyses
6. Centrifugal and Axial Flow Compressors
7. Axial and Radial Flow Turbines
8. Inlets and Nozzles
9. Combustion and Burners
10. Component Matching
11. Engine Performance Analysis
12. Environmental Aspects – Noise and Emissions

Books and References:

1. ***Aircraft Propulsion***, by S. Farokhi, 2nd Edition, Wiley, 2014 (ISBN 1-56347-779-3). (**Required Text** – *This is a well-written book, an excellent reference as well as a text. We will be using this book for some reading and homework assignments*).

2. ***Jet Propulsion***, by N. A. Cumpsty, Cambridge University Press, 2005 (ISBN 0-521-541441). **Call # TL709.3.T83 C85 2003** (*Supplementary*. *This book written by a leading gas turbine engine designer gives a step-by-step practical design example of a modern gas turbine engine*).

3. ***Compressor Aerodynamics***, by N. A. Cumpsty, Krieger Publishing Co, 2004 (ISBN 1-57524-247-8). **Call # TJ267.5.C5C86 2004** (*A comprehensive treatment of the arguably most critical component of a gas turbine engine, compressors. Ideal for a 6000 level course on the topic*).

4. ***Elements of Propulsion – Gas Turbines and Rockets***, by J. D. Mattingly, AIAA Education Series, 2006 (ISBN 1-56347-779-3). **Call # TL709.M388 2006** (*This book has a comprehensive treatment of gas turbine cycle analysis*).

5. ***Fundamentals of Jet Propulsion with Applications***, by R. D. Flack, Cambridge University Press, 2005 (ISBN 0-521-81983-0). **Call # TL709.F5953 2005** (*This text is very well-written but notations are irksome making it unsuitable as a text for this course*).

6. ***Theory of Aerospace Propulsion***, by P. M. Sforza, Elsevier, 2012 (ISBN 978-1-85617-912-6). **Call # TL709.S38 2012** (*This book was used as the text for ASEN 4013 for the past few years*).

7. ***An Introduction to Aerospace Propulsion***, by A. R. Douglas and M. Saarlas, Prentice Hall, 1996 (ISBN 0-13-120496-3). **Call # TL709.A7 1996** (*This book covers both gas turbines and rockets, and has a chapter on thermodynamic cycles and environmental impacts such as noise and sonic boom*).

8. ***Aircraft Engine Design***, 2nd Edition, by J. D. Mattingly, W. H. Heiser, and D. T. Pratt, AIAA Education Series, 2002 (ISBN 1-56347-538-3). **Call # TL709.5.T87 M38 2002** (*This*

book deals with design of aircraft engines, with a specific example of an engine for an advanced air-to-air fighter).

9. ***Aircraft Engines and Gas Turbines***, 2nd Edition, by J. L. Kerrebrock, MIT Press, 2001 (ISBN 0-262-11162-4). **Call # TL709.K46 1992 (***A 6000 level book by the ex-director of the Gas Turbine Laboratory at MIT. Well-written and includes some other important aspects of aircraft engines such as engine noise and hypersonic engines*).

10. ***Principles of Turbomachinery in Air-Breathing Engines*****,** E. A. Baskeharone. Cambridge University Press, 2006 (ISBN 978-0-521-85810-6). **Call # TJ778.B33 2006** (*Good book on turbomachinery*).

11. ***Aerospace Propulsion***, by T.-W. Lee, Wiley, 2014 (ISBN 978-1-118-30798-4) (*An elementary treatment better suited for a 4000 level course*).

12. ***Aircraft Propulsion***, by V. Babu, CRC Press, 2009 (ISBN 1-43981-271-3) (*An elementary treatment*).

13. ***Mechanics and Thermodynamics of Propulsion***, 2nd Edition, by P. Hill, and C. Peterson, Addison Wesley, 1992 (ISBN 0-201-14659-2). **Call # TL709.H5 1992 (***A classic but dated. Remains a valuable resource on aerospace propulsion. It devotes about 1/3 each to fundamentals, air-breathing and rocket propulsion*).

14. **Gas Turbine Theory,** 4th Edition, by H. Cohen, GFC Rogers and HIH Sravanamutto, T. J. Press, 1996 (ISBN 0-582-23632-0). **Call # TL778.C6 1996** (*Classic but somewhat dated).*

Journals:

AIAA Journal of Propulsion and Power
AIAA Journal of Aircraft
AIAA Journal
ASME Journal of Engineering for Gas Turbines and Power
ASME Journal of Turbomachinery

Logistics:

We will make use of D2L, in order that I may upload my lecture notes for you to download, post homeworks, homework solutions and grades, and make the whole process a bit more efficient than the hard copy-route. All communication, including e-mails, will be through D2L. All homework and assignments should be submitted in electronic form (.pdf, .docx, .ppt, .xlsx formats) with following naming convention: HW#_LastName.pdf . The same goes for other assignments with HW replaced by QZ, Exam or Finals.

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