AAE 537 Hypersonic Propulsion
Course Organization and Information

Fall Semester, 2021

Instructor: Professor S. D. Heister (AAE)
Office: 2019 Armstrong, (e-mail: heister@purdue.edu)
AAE Propulsion Website: http://roger.ecn.purdue.edu/~propulsi/propulsion/ **Office Hours:** TBD (or by appointment)
Teaching Assistants: Ariana Martinez (after 9/12/19) marti730@purdue.edu
Office: Chaffee Hall Ph. 494-xxxx
Office Hours: T 10:30a.m.-12:00p.m, Th 7:00-8:30 p.m. (via Webex)

Text: There is no formal text for the class but numerous papers/materials will be shared on blackboard site. The reference books below are all on the course website as PDFs.

1. **Curran, E. T. and Murthy, S.N.B., *Scramjet Propulsion*, 2001**

Visit http://guides.lib.purdue.edu/az.php Search 'AIAA' in database. Select 'AIAA Aerospace Research Central'. In the search bar use ISBN #: 978-1-60086-660-9.

2. **Murthy, S.N.B, *Developments in High-Speed Propulsion*, 1996**

In the AIAA research central search bar use ISBN #: 978-1-60086-640-1.

3. **Murthy, S.N.B., and Curran, E. T., *High-Speed Flight Propulsion Systems*, 1991**

In the AIAA research central search bar use ISBN #: 978-1-60086-610-4

4. **Heiser, W.H. and Pratt, D. T., *Hypersonic Airbreathing Propulsion*, 1994.**

Visit https://www.lib.purdue.edu/ and search 'Hypersonic Airbreathing Propulsion'. Open the first link. Read the book 'Knovel Aerospace Radar Technology Academic'. You can download a limited number of pages from Knovel.

5. **Segal, C., *The Scramjet Engine*, Cambridge University Press, 2009**

Visit https://www.lib.purdue.edu/ and search 'The Scramjet Engine'. Using the first link, go to Ebook Central Academic Complete and read the book. You can also download Adobe Digital Edition and borrow all these books.

Instructor will point you to specific chapters that augment lecture materials.

Prerequisites: AAE 439 *and* AAE 339 or permission of instructor. Students in the class are expected to be familiar with the basic thermodynamics of the gas turbine engine cycle and treatment of the various components (compressor, combustor, turbine, etc). Some level of exposure to rocket propulsion is also assumed with knowledge of basic thermodynamics and the characteristic velocity (c*) and thrust coefficient (c_f) performance parameters. Remedial materials can be suggested for those who need to catch up.

Homework: All assignments are to be uploaded to Gradescope (link provided in Brightspace course webpage) by the designated time and are to be graded using Gradescope software. Late assignments will be not be accepted for any reason.

Exams: A two hour midterm will be scheduled on Wednesday 6 October from 8-10 pm for all on campus students. Distance students will also need to take the exam on this day with their proctors.

Final Design Project: Each of the teams will submit a final report providing a detailed design of a hypersonic propulsion system. The report should contain sufficient detail to identify the flow conditions at all stations within the device - more details on the final project to follow.[1]

Course Grading:

Homework - 20%

Midterm Exam - 30%

Final Design Project - 50%

Attendance: Class attendance is optional and recorded lectures will be available to the on-campus class due to distance format – if you are on campus, I encourage you to attend class

Purdue Honors Pledge: *As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do*. For more info, s ee: https://www.purdue.edu/provost/teachinglearning/honor-pledge.html

Useful Media

An interesting, and rather comprehensive news release came out on scramjet technology on 5 August 2019:

https://www.thedrive.com/the-war-zone/29307/air-force-reveals-tests-of-supposed-record-setting-scramjet-engine-from-northrop-grumman

[1] Flu Pandemic Procedures: We will communicate via email should the University close for flu pandemic. Instructor reserves the right to modify grading policies in the event of an emergency of this type.

Course Outline

1. Introduction – Hypersonic propulsion missions, classification of systems, mission analysis, modified rocket equation (3 lectures)

2. Inlets/Compression Systems – inlet types, inlet starting, analysis of 1, 2, and 3 shock inlets, isentropic spike inlets, isolators (4 lectures)

3. Mixers – constant area and constant pressure mixer, incompressible and compressible shear layers (4 lectures)

4. Turbine-Based Systems for High-Speed Flight: Cycle analysis, water/fluid injection, afterburning, turboramjets, performance calculations (2 Lectures)

5. Pulse/Rotating Detonation Engines: Principles of operation, Chapman-Jouget detonations, performance analysis (4 Lectures)

6. Ramjets/Scramjets: Cycle analysis, 1-D internal flow analysis, performance calculation. (4 Lectures)

7. RBCC Systems/Ducted Rockets: Cycle analysis, 1-D internal flow analysis, performance prediction (2 Lectures)

8. Cooling/heat transfer analysis – film, transpiration and convective cooling, cooling with hydrocarbon fuels (2 lectures)

9. Guest Speakers (1-2 Lectures)

10. X-43 brief, other things I dig up (1 lectures)

11. Presentation of concept designs from each group (3-4 Lectures)

Final Grades: A grade is assigned at the end of the semester based on a curved scale of all students in class. Those who have demonstrated an excellent understanding of hypersonic propulsion will be given an A+, A, or A- grade. Those who have demonstrated a minimum acceptable understanding will receive a C+, C, or C- grade with B grades falling in between these extremes. Those who have demonstrated an unacceptable level of understanding will receive a D or F grade.

Learning Outcomes: Learning outcomes and objectives will be detailed on each assignment

Nondiscrimination Statement
Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. Link to Purdue's nondiscrimination policy statement.

Accessibility and Accommodations
Purdue University strives to make learning experiences accessible to all participants. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let us know so that we can discuss options. We also encourage you to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247.

Mental Health
If you find yourself beginning to feel some stress, anxiety and/or feeling a bit overwhelmed, try WellTrack, https://purdue.welltrack.com/. Sign in and find information and tools at your fingertips, available to you at any time.

If you need support and information about options and resources, please see the Office of the Dean of Students, http://www.purdue.edu/odos, for drop-in hours (M-F, 8 am - 5 pm).

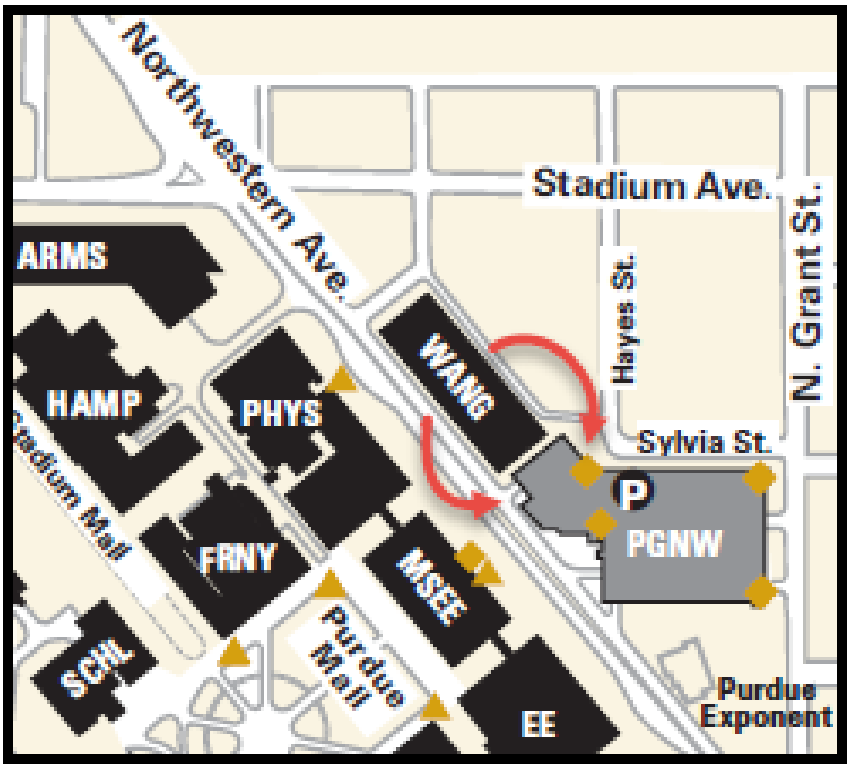
If you are struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at (765)494-6995 and http://www.purdue.edu/caps/ during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

EMERGENCY PREPAREDNESS

EMERGENCY NOTIFICATION PROCEDURES are based on a simple concept – if you hear a fire alarm inside, proceed outside. If you hear a siren outside, proceed inside.

- **Indoor Fire Alarms** mean to stop class or research and immediately **evacuate** the building. Proceed to your Emergency Assembly Area away from building doors. **Remain outside** until police, fire, or other emergency response personnel provide additional guidance or tell you it is safe to leave.
- **All Hazards Outdoor Emergency Warning Sirens** mean to immediately seek shelter (**Shelter in Place**) in a safe location within the closest building.
    - "Shelter in place" means seeking immediate shelter inside a building or University residence. This course of action may need to be taken during a tornado, a civil disturbance including a shooting or release of hazardous materials in the outside air. Once safely inside, find out more details about the emergency*. **Remain in place** until police, fire, or other emergency response personnel provide additional guidance or tell you it is safe to leave.

**In both cases, you should seek additional clarifying information by all means possible…Purdue Emergency Status page, text message, Twitter, Desktop Alert, Albertus Beacon, digital signs, email alert, TV, radio, etc.…review the Purdue Emergency Warning Notification System multi-communication layers at http://www.purdue.edu/ehps/emergency_preparedness/warning-system.html*



Additional info specific to Wang Hall:
https://engineering.purdue.edu/ECE/Safety/WANG_BEP_2014-2015.pdf

- **CAPS Information**: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at (765)494-6995 and http://www.purdue.edu/caps/ during and after hours, on weekends and holidays, or through its counselors physically located in the Purdue University Student Health Center (PUSH) during business hours.
- Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. Purdue's nondiscrimination policy can be found at: http://www.purdue.edu/purdue/ea_eou_statement.html.