Course Information

- **Course number and title:** MSE 51700 Materials for Hypersonics
- **CRN:** 21998 EPE
- **Instructional Modality:** Async-Online
- **Course credit hours:** 3
- **Prerequisites:** Graduate standing OR concurrent prerequisite with MSE 330
    - No prerequisites for MSE graduate students or other engineering graduate students

Instructor(s) Contact Information

- **Name of the instructor:** Prof. Rodney Trice
- **Office Location:** Neil Armstrong Hall of Engineering, Rm. 2227
- **Office Phone Number:** 765-494-6405
- **Purdue Email Address:** rtrice@purdue.edu
    - *I will try and respond to emails within 24 hrs; emails are read between 8 am-5 pm eastern time*
    - *Please use your official Purdue email when corresponding with me; please include "MSE 517" in the byline.*
    - **Office Hours Tuesday 4:30 – 5:30 eastern time or set up by email; Location: *https://purdue.webex.com/meet/rtrice***

Course Description

This course will include a brief history of hypersonic flight and design, along with a description of the aerothermal environment, to provide motivation for the use of ceramic materials as thermal protection systems and window materials. The classroom approach is to develop a fundamental understanding of materials structure, forming and sintering, and properties (mechanical and thermal) of ceramics, and then apply that knowledge for hypersonic applications such as ultra-high temperature ceramics (UHTCs including ZrB_2), ceramic matrix composites (including C_f/SiC, SiC_f/SiC, and Carbon/Carbon), and materials requirements for RF and IR radomes and windows.

Learning Resources, Technology & Texts

- **Informed Learning resources:**
    - **Reference texts**
        - To access the reference readings listed here, use the PWL Library Reading List link in the Reference Readings module in Brightspace.
            - Advanced Sandwich Structures for TPS.pdf
            - ASTM C 1181 Standard Test Method for Flexural Strength of Advanced Ceramics at Ambient Temperature.pdf
            - ASTM C 1239 Weibull Standard.pdf
            - Bertin, Cummings - 2003 - Fifty Years of Hypersonics Where We've Been, Where We're Going-annotated.pdf
            - Fahrenholtz, Alfano - 2014 - Ultra-high Temperature Ceramics: Materials for Extreme Environment Applications.pdf
            - Korkegi - Shock Shock - Survey of Viscous Interactions Associated with High Mach Number Flight-annotated.pdf
            - Mack, Andres - 2007 - Aerothermodynamic Behaviour of a Generic Nosecap Model Including Thermomechanical Structural Effects.pdf
            - Pelz, Ku, Meyers, Vargas-Gonzales - 2021 - Additive Manufacturing of Structural Ceramics: A Historical Perspective.pdf

        - Quinn, Morrell - 1991 - Design Data for Engineering Ceramics: A Review of the Flexure Test.pdf
        - Quinn, Quinn - 2009 - A Practical and Systematic Review of Weibull Statistics for Reporting Strengths of Dental Materials.pdf
        - Squire, Marschall - 2010 - Material Property Requirements for Analysis and Design of UHTV Components in Hypersonic Applications.pdf
        - Tracy, Wright - 2020 - Modeling the Performance of Hypersonic Boost-Glide Missiles.pdf
        - Van Wie et al. - 2005 - Hypersonic Airbreathing Propulsion-annotated.pdf
    - To access the reference readings listed here, use the direct links to each article listed in the Reference Readings module in Brightspace.
        - D Glass - Ceramic Matrix Composite (CMC) Thermal Protection Systems (TPS) and Hot Structures for Hypersonic Vehicles.pdf
        - Marshall et al. - 2014 - National Hypersonic Science Center for Materials and Structures Final Report Prepared for Dr. Ali Sayir.pdf
- **Lecture Notes**
    - MSE 517 Notes with Blanks
        - PPTX slides to be used in conjunction with lecture videos.
- **Software/web resources**
    - Gradescope
        - All graded assignments, and exams will be submitted by the due dates in Gradescope
- **Hardware requirements**
    - Computer for watching videos, accessing all course content, etc
    - Printer or iPad/Tablet for taking exams
- **Brightspace learning management system**
    - Students will access all course materials, videos and readings, discussions, assignments, and exams in **MSE517 Materials for Hypersonics** via Brightspace.
- **All students** will be uploading their exams on gradescope.com to facilitate my efficiency at getting you feedback on your performance. Thus, you will not be submitting any "paper" copies to Prof. Trice/TA this semester. Your registration information for the class has been linked from Brightspace to gradescope.com. More details to follow.

Course Learning Outcomes

1. List and differentiate the basic history of hypersonic flight including the X-15a and current vehicles.
2. Articulate the features of the aerothermodynamic environment as it relates to hypersonic flight; describe different flight trajectories; apply the first law of thermodynamics to an aircraft leading edge; draw the basic thermal protective systems.
3. Articulate processing of high-temperature ceramic materials, from colloidal design to forming methods such as additive manufacturing
4. Calculate flexure strength and Weibull modulus, and fracture toughness of ceramic materials.
5. Articulate how bonding and microstructure affect thermal properties and how these affect thermal protective systems.
6. Explain how thermal and mechanical properties are important for leading edge and TPS in hypersonic aircraft, and the fundamentals of ablative coatings.
7. Describe the basic material requirements for radar frequency and infrared frequency windows for hypersonic flight, and the microstructural requirements for each.
8. Describe the basics of ceramic matrix composites including fibers and matrices commonly used, and the role of debond coating design.
9. Explain the use of high emittance coatings in leading-edge design to radiatively cool.

Assignments and Assessments

Your achievement of course learning outcomes will be assessed through a combination of homeworks, three exams spread throughout the academic period. Details on these assignments and exams, including a schedule of due dates, rubrics to guide evaluation, and guidelines on discussion participation and evaluation will be posted on the course website.

Exam I	25%
Exam II	30%
Final Exam	30%
Homeworks	15%

- Each module, you will have the opportunity to achieve course learning outcomes through assignments that can be completed and uploaded to Gradescope.
  - Please read the feedback that I provide for ways to enhance your learning going forward and consult with me for questions and additional support.
- Homeworks (15% of your grade). These homeworks relate to course learning outcomes and involves a self-analysis of your understanding and capability to complete the fundamental skills of the class. Homework 7 will require preparation and presentation of 2-3 slides on a subject matter of interest to you and will count for a high points value. Further information will be given later.
- Exams (85% of your grade).

Examination Dates and Further Instructions

Exam 1:	Feb 15
Exam 2:	April 4
Final Exam:	Aril 29-May 3 TBD

All examinations are closed-book but you may use up to 1 sheet of HANDWRITTEN notes (8.5" x 11", two sides). Besides this crib sheet, the only other things allowed for the exams are writing implements, eraser, straight edge (ruler), and a calculator. *You cannot use your phone as a calculator but please bring your phone to the exams to upload your exam to Gradescope. You need to be able to print of the exam or take it on a tablet that you can write/draw on.*

Make-up exams will be given only for the following verifiable reasons: serious illness, family emergencies, direct conflict with another scheduled exam (must inform instructor no later than two weeks prior), or official university absence.

Grading appeals will be considered up to 5 days after an exam is returned to you. Exam regrade requests will be handled through Gradescope (see below); provide a brief, logical explanation of the basis in your appeal. I do make mistakes grading and am happy to take a look, but please no whining; just present your case.

Grading Scale

This represents the typical grade scale used for this class:

90% and above: A
70% -90%: B
60% -70% : C
50% -60% : D
49% and below: F

Every semester I receive multiple emails asking if there is a way to obtain extra credit in the class. There is not. Your course grade will come from these the three exams and homeworks.

Absences

Although this is an online course, you should contact me if something arises in your personal life that will impact your ability to complete your online coursework. University regulations concerning absences are updated on the Office of the Dean of Students website.

If you have a death in the family, you (or your representative) should contact the Office of the Dean of Students. That office will then notify your instructors. Check the Grief Absence Policy on Purdue's website.

If you are called up for active duty or mandatory military training, your commanding officer can provide the Dean of Students a copy of your orders. The Dean of Students may then contact your instructors; however, please let me know at the beginning of the semester if you expect to be absent for military duty.

If you need to adjust deadlines for a religious observance, you must let me know a week in advance, minimize the length of your absence, and be flexible in arranging alternative times to complete the assignments you may miss.

Course Schedule

The course schedule is **required** and provided as a separate document in your course Brightspace course. The schedule outlines the content of the course with available and due dates for assignments, exams 1,2 and 3, readings and discussions.

- You can access the course schedule in the Brightspace course left-side navigation menu or click the **MSE517 Materials for Hypersonics Course Schedule**.
- For key University dates for the semester, see the Purdue Academic Calendar.

Academic Integrity and Copyright

"As a Boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue."

Purdue's Honor Pledge:

- All assignments and exams must be your individual work and cannot be completed or submitted by others or surrogates.
- **Exams** must be completed fully individually without any on-time consultation of others or of any electronic resources not specifically listed in the exam guidelines. All exams are available online during predefined timeslots.
- **Assignment submissions and quizzes responses** must be completed and submitted individually. However, you are allowed to consult with others in the class and use external and course related resources to complete the assignments.
- Incidents of academic misconduct in this course will be addressed by the course instructor and referred to the Office of Student Rights and Responsibilities (OSRR) for review at the university level. Any violation of course policies as it relates to academic integrity will result minimally in a zero grade for that particular assignment, and at the instructor's discretion may result in a failing grade for the course. In addition, all incidents of academic misconduct will be forwarded to OSRR, where university penalties, including removal from the university, may be considered.

Purdue University's Student Conduct Rules
https://catalog.purdue.edu/content.php?catoid=16&navoid=19689&_ga=2.197042858.76024265.1702163117-387856188.1701722407#regulations-governing-student-conduct-disciplinary-proceedings-and-appeals *state:*

i. *Cheating: Students are expected to adhere to the guidelines provided by instructors for academic work so that no student gains an unfair advantage. Using or attempting to use unauthorized materials, information, study aids, notes, or any other device in any academic exercise will not be tolerated.*

Unauthorized materials may include anything which or anyone who gives a student assistance that has not been approved by the instructor in advance.

ii. *Plagiarism: Intentionally or knowingly representing the words or ideas of another as one's own in any academic exercise, without proper attribution. The sole exception of the requirements of acknowledging sources is when the information is considered common knowledge. Plagiarism includes "self-plagiarism", which is reusing portions of the student's previously written text and/or assignments, without acknowledgement or proper attribution.*

iii. *Fabrication: Intentional and/or unauthorized falsification or invention of any information or citation in any academic exercise. Includes but is not necessarily limited to (A) the changing and/or manipulation of research data, results, processes, or research record; (B) the omission of results from the research record; and (C) the alteration and resubmission of a graded academic exercise.*

iv. *Multiple Submissions: The submission of substantial portions of the same academic work for credit more than once without authorization from the instructor.*

v. *Collusion: Intentionally or knowingly helping or attempting to help another to violate any regulation governing the standards of academic integrity described in these regulations. Students may only collaborate on academic work within the limits prescribed by the instructor.*

Copyright: Lecture materials, as well as videos provided by the instructor are subject to the instructor's copyright. Course notes are considered to be 'derivative works' of the instructor's presentations and materials, and they are thus subject to the instructor's copyright. This instructor does not give permission for any such material to be sold or bartered. This includes uploads to commercial note sharing websites (including, but not limited to, CourseHero and Chegg).

Software: If accessing software through Purdue University, follow all respective license agreements.

AI: ***The use of AI tools to complete course assignment is not allowed and students are expected to complete all assignments and deliverables as part of their own personal effort.*** If the use of AI is detected as part of submitted solutions, grades will be invalidated, and the conduct be treated as violation of academic honesty.

In the Start Here Module of the Brightspace course find the submodule titled: "University Policies and Statements". In this submodule, locate the first hyperlink "Purdue's Student Guide for Academic Integrity" which links you to the Office of Student Rights and Responsibilities Academic Integrity webpage. The last hyperlink in the list is "Use of Copyrighted Materials" that links to a University Policy Office webpage. Be sure to familiarize yourself with other University Polices and Statements in the list.

Nondiscrimination Statement

Also, in the Start Here Module in the Brightspace course is a link to Purdue's Nondiscrimination Policy Statement located in the University Policies and Statements submodule. You may access it direct or by using the policy link in Brightspace.

Accessibility

Ensuring that Purdue students have access to equitable learning experiences is a University-level commitment and is the responsibility of all members of the Purdue community. The Disability Resource Center (DRC) is a key partner in this work and is a resource for students and instructors.

The Student Services widget links to the DRC. In the Start Here module, the Student Support and Resources widget provides information for the Disability Resource Center (DRC). You are encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247 if you need further assistance.

Mental Health/Wellness Statement

If you're 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 during and after hours, on weekends and holidays, or by going to the CAPS office on the second floor of the Purdue University Student Health Center (PUSH) during business hours.

If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try WellTrack**.** 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 contact or see the Office of the Dean of Students. Call 765-494-1747. Hours of operation are M-F, 8 a.m.- 5 p.m.

If you find yourself struggling to find a healthy balance between academics, social life, stress, etc., sign up for free one-on-one virtual or in-person sessions with a Purdue Wellness Coach at RecWell. Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is free and can be done on BoilerConnect.

Basic Needs Security

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact the Dean of Students for support. There is no appointment needed and Student Support Services is available to serve students 8 a.m.-5 p.m. Monday through Friday.

In addition to the availability of the Dean of Students, you may also want to familiarize yourself with some of the following resources:

- *ODOS services and information portal* and the *Critical Need Fund*.
- *Student of concern reporting* (anyone on campus can submit a report if they are unsure where to go or in what way they can help a student - it does not need to be an emergency).
- The *ACE Campus Food Pantry* (open to the entire Purdue community)
- The *Center for Advocacy, Response & Education (CARE)* (open to all Purdue students) "provides support and advocacy for survivors of sexual violence, dating violence, and stalking.

Emergency Preparedness

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors or TAs via email or phone. You are expected to read your @purdue.edu email on a frequent basis.

A link to Purdue's Information on Emergency Preparation and Planning is located in the Start Here module in our Brightspace course under "University Policies and Statements." This website covers topics such as Severe Weather Guidance, Emergency Plans, and a place to sign up for the Emergency Warning Notification System.

Disclaimer

The instructor reserves the right to adjust and/or make changes to this syllabus and the course schedule as needed. Students will be notified via announcements on the course homepage in Brightspace.