MAE 640: Rocket Propulsion II

Course Information

Contact

Instructor:	Dr. Robert A. Frederick, Jr.
Office:	TH S231
Email Address:	Robert.Frederick@uah.edu (Email answered within 24 - 48 hours)
Phone Numbers:	256-503-4909 (cell)
Availability/Office Hours:	Online Zoom Office Hours Posted in Canvas

Details

Course Name:	Rocket Propulsion II
Mode of Delivery:	MAE 640-01 on campus/MAE 640-01R Remote
Credit Hours:	3
Semester/Year:	spring/2023
Meeting day, time, location:	Monday, Wednesday, OKT S117 Live Zoom at Class Meeting Time
Prerequisites:	MAE 540 or permission of instructor

Overview

Rocket Propulsion II, MAE 640 will expand and go deeper on many topics introduced in MAE 540, Rocket Propulsion I such as thermochemistry, nozzle design, and trajectory analysis. Some homework problems will delve deeper into the derivation from fundamental principles of the equations presented in the book. This course covers additional topics beyond MAE 440/540 such as Hybrid Rockets and additional liquid rocket topics. Programmed outside reading of current/past literature provides content that is not in the book. The project integrates the basic and advanced components of the course into a system design study to fulfill mission requirments.

Objectives

Upon completion of this course, the student will be able to:

- to define key rocket propulsion terms.
- to calculate component and systems performance using rocket propulsion principles.
- to design a rocket combustor or propulsion system to meet specific design objectives using thermochemical codes, design equations, and relevant technical literature.

Materials

Aerothermodynamics of rocket propulsion systems; rocket propellants and combustion; heat transfer and cooling problems. Application to ramjets and hybrid systems. Prerequisite: MAE 540 or permission of instructor.

Required

- Heister, S. D., Anderson, W.E., Pourpoint, T. L., and Cassady, R.J. Rocket Propulsion, Cambridge Aerospace Series, 2019, Hardback, ISBN: 9781108422277
- Heister, S. D., Anderson, W.E., Pourpoint, T. L., and Cassady, R.J. Rocket Propulsion, Cambridge Aerospace Series, 2019, Online, ISBN: 9781108422277, FORMAT: Adobe eBook Reader, ISBN: 9781108397100

This book provides excellent tutorial descriptions of rocket propellant principals and challenging homework problems.

Additional/Recommended

- Sutton, G.P., and Bilbartz, O. Rocket Propulsion Elements - 9th Edition, Wiley, Hardback, ISBN: 9781108422277

  This book provides a wealth of reference material and detailed descriptions of rocket propulsion principles.

Technology Statement

This course will use UAH's learning management system, Canvas, as well as other technology tools. Students will be expected to have access to a computer with internet capabilities in order to fully participate in this course. Any online exams will require students to scan or photograph exam papers and upload them as one file to CANVAS**.**

MAE 640-01R(emote) Participating in an remote online course has many benefits like flexibility, convenience, and greater control over the timing of your learning You will stay motivated and on-task throughout the semester by keeping up with lectures and assignments. Canvas also provides your instructor data about your interactions with online class materials.

The class will also use CEQUEL^{TM} which works in conjunction with Microsoft Excel on a PC. In the past, we have provided remote access to PCs if students are Mac users. There is a declaration for using CEQUEL for academic purposes only.

Material Covered

This course adopts a format for both online and in class presentation. The instructor uses multiple instructional methods including lectures, oral presentations with an associated critical discussion, supplementary lectures, assigned reading, and interpretive discussions. The instructor typically covers material for each module in 2 to 4 lectures. The instructor also provides or directs students to relevant literature that either illustrates current research into the topic or explores a relevant additional concept.

The following modules each provide lectures, homework, quizzes, and supplementary material to achieve specific learning objectives

- Module 01 Fundamental Concept Review (Chapters 1, 2, 3, 4)
- Module 02 Hybrid Rocket Engines (Chapter 11)
- Module 03 Combustion and Thermochemistry (Chapter 5)
- Module 04 Heat Transfer in Chemical Rockets (Chapter 6)
- Module 05 Liquid Rocket Engines (Chapter 8)
- Module 06 Liquid Rocket Propellants (Chapter 9)
- Module 07 Turbomachinery and Combustion Instability (Chapters 10, 12)
- Module 08 Class Project (Supplementary Material on Solid Fuel Ramjet Engines)

Select material from the following chapters in the book will be reviewer/covered:

- Chapter 1 Classification of Propulsion Systems and Historical Perspectives
- Chapter 2 – Mission Analysis Fundamentals
- Chapter 3 – Trajectory Analysis and Rocket Design
- Chapter 4 – Rocket Nozzle Performance
- Chapter 5 - Combustion and Thermochemistry
- Chapter 6 – Heat Transfer in Chemical Rockets
- Chapter 7 – Solid Rocket Motors
- Chapter 8 - Liquid Rocket Engines
- Chapter 9 – Liquid Rocket Propellants
- Chapter 10 – Rocket Turbomachinery Fundamentals
- Chapter 11 – Hybrid Rocket Engines
- Chapter 12 – Combustion Instability

Evaluation and Grading

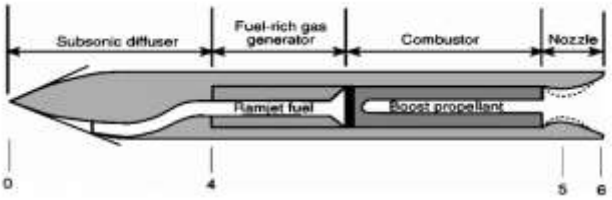
The following grading scheme for your overall course average will apply in this course:

A = 90.00%–100%; B = 80.00%–89.99%; C = 70.00%–79.99%;
D = 60.00%–69.99% F < 60.00%

Weighted assignment groups provide the basis for the final course average:

Assignment Types	What to Expect	%
Quizzes	The Quizzes assess the knowledge that you have acquired in a particular module. They are generally facts from the textbook or assigned outside reading. They can also have short calculation problems to assess execution of a concept. There are up to 20 quizzes in this course. There may be some in lecture quizzes that are used to assess the students' current skills and level of participation in lecture.	15% (drop 2)
Homework	The Homework assesses your ability to calculate propulsion component and system performance using rocket propulsion principles. It is submitted in a 9-Step format (detailed and illustrated in a later sections) unless otherwise stipulated in the assignment instructions in writing.	20% (drop 1)
Project Assignments	The Project Assignments establish team plans, verify new software routines, integrate algorithms, and promote teamwork skills for the success of your final project report. You and your assigned project partner will complete each Project Assignment together and make joint submissions.	5% (joint grade)
Exam 1	Exam 1 will cover Modules 1, 2, and 3. The exam will include quiz questions and 2 or 3 longer problems worked in the homework format and uploaded. All students will take Exam 1 online.	20%
Exam 2	Exam 2 will cover Modules 4, 5, and 6. Students should expect to use skills from the previous modules for Exam 2. Exam 2 will include quiz questions and 2 or 3 longer problems worked in the homework format and uploaded. All students take Exam 2 online.	20%
Final Exam	The Final Exam consists of the Class Project Report (you and your project partner receive one grade). Each team will also make a brief oral summary of their project report during the final exam period.	20% (joint grade)

The course project for the spring 2023 class will use the principles of solid rockets, hybrid rockets to compare designs among: [A] pure solid propulsion, [B] hybrid, and a [C] solid boost/ramjet combustor design for a supersonic mission to achieve the greatest range. The instructor provides additional instructional material and students research supplementary technical papers on the ramjet component of this project that are not contained in the textbook. The instructor provides a Project Requirement Document that describes the mission requirements, guidelines and assumptions, and a list of technical symbols for the project.



Canvas randomly assigns project partners for the project/final exam. If you have special needs beyond your preference for a particular person regarding selection of a project partner, email the instructor the first week of class. The instructor and the instructional design team built all material and assignments in this course for remote interactions, so face-to-face meeting to complete the project are not required, but they are encouraged.

The instructor uses grading rubrics to determine scores for each element of an assignment or exam. Canvas algorithms generally automatically grade quizzes making the overall score available immediately upon submission. The assignment drop box usually contains the grading rubric so students can see the success criteria when starting the assignment and reviewing their subsequent scores. In general, all assignments will be graded and returned to students within one week.

Teaching assistant(s) grade assignments. The graders will provide written feedback and annotations on the assignment to the students. You should direct initial questions about homework grading to the teaching assistant. The student can also approach the instructor if further discussion would be helpful. The instructor will post assignment solutions after all the assignments are graded.

Missed Assignments/Make-Ups/Extra Credit

To compensate for the normal uncertainties of life, the Canvas will automatically drop the lowest homework score and your lowest two quizzes. This class has a very straightforward late policy: Late homework will be deducted one point per minute late (negative points are not possible). "Late" is defined as “marked late by the Canvas drop box.” The exam drop box will contain any specific variations of this late policy for exams.

If you have an event that is beyond your control that prevents you from submitting your assignment on time, please go ahead, submit your assignment as soon as you can on Canvas, and provide the instructor with a written description of the external event that prevented you from submitting your assignment. If appropriate, you may also call the instructor 256-503-4909 to

explain an urgent matter. Examples of life events such as a death in the family, illness, or a pre-approved professional conflict such as participating in a conference, etc.

Any extra credit opportunity will be available to all students and posted in the instructions on a particular assignment.

Below is the required Homework Format (See Example at end of this Syllabus). In the solution of problems, you are **required** to provide the following heading and sections:

1. **Name:** Provide name of the student
2. **Given:** State briefly and concisely (in your own words) the information provided.
3. **Find:** State the information that you have to find
4. **Schematic:** Draw a schematic representation of the system and control volume if applicable.
5. **Assumptions:** List the simplifying assumptions that are appropriate to the problem and implied by the equations used.
6. **Basic Equations**: Outline the basic equations needed to do the analysis.
7. **Analysis:** Manipulate the basic equations to the point where it is appropriate to substitute numerical values. Substitute numerical values (using a consistent set of units) to obtain a numerical answer. *Include appropriate units in calculations.* If multiple repetitive calculations are done in a spreadsheet for example, show at least one example calculation in detail. The significant figures in the answer should be consistent with the given data. Check the answer and the assumptions made in effecting the solution to make sure they are reasonable.
8. **Answer:** Label the answer(s) with a box and/or arrow from the right-hand margin.
9. **Comment:** Write a comment at the end of the homework that reflects on the limitation of the solution, the reasonableness of the solution, or something that you learned by doing the problem.

The student must show all nine formatting elements in each homework assignment to receive full credit unless otherwise specified.

Attendance Policy

MAE 640-01 students are expected to attend class in person whenever possible. MAE 640-R are encouraged to join class via live Zoom at the scheduled class time. The instructor will post Zoom videos of lectures and appropriate portions of help sessions on Canvas within 24 hours of the end of the filming session.

Canvas will deploy Exam 1 and Exam 2 in an online format. The instructor expects MAE 640-R (remote) students to take the Exam 1 and Exam 2 during the scheduled class time for those exams unless the instructor approves another time in writing beforehand. All students will be able to take Exam 1 and Exam 2 remotely.

Example Homework Problem Worked in 9-Step Format

PAGE 1 OF 1

1. NAME: ROBERT FREDERICK, HW #1

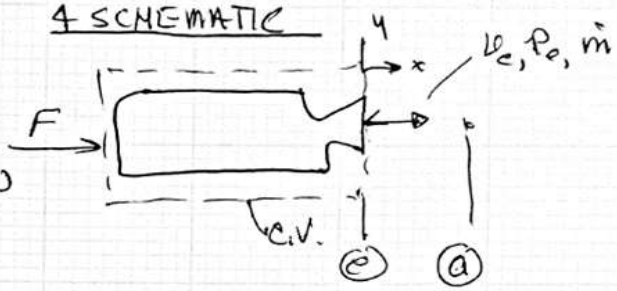
2. GIVEN ROCKET MOTOR WITH THE FOLLOWING PROPERTIES

$\dot{m} = 10 lbm/s$, $V_e = 6{,}000 ft/s$, $P_e = 10.0 lbf/in^2$

$A_e = 5 IN^2$, $P_a = 14.7 lbf/in^2$

3. FIND (a) ROCKET THRUST

4. SCHEMATIC



5. ASSUME

(a) STEADY-STATE
(b) ONE-DIMENSIONAL FLOW
(c) ADIABATIC FLOW

6. BASIC EQUATIONS

$$F = \dot{m} V_e + (P_e - P_a) A_e$$

7. ANALYSIS

$$F = \left(10 lbm/s\right)\left(6{,}000 \frac{ft}{s}\right)\left(\frac{lbf \cdot s^2}{32.2 lbm\, ft}\right) + \left(10 \frac{lbf}{in^2} - 14.7 \frac{lbf}{in^2}\right)\left(5.0 in^2\right)$$

$$F = 1863.3 lbf - 23.5 lbf = \boxed{1840 lbf} \leftarrow \text{ANSWER (a)}$$

9. COMMENTS

(a) IMPORTANT CONVERSION FACTOR $1 = \frac{32.2 lbm\, ft}{lbf \cdot s^2}$

(b) MOMENTUM THRUST ($\dot{m} V_e$) IN MAJORITY OF THRUST

(c) PRESSURE THRUST IS NEGATIVE (NOZZLE OVEREXPANDED)

(d) SPECIFIC IMPULSE WOULD BE

$$I_s = \frac{F}{\dot{m} g} = \frac{1840 lbf}{\left(\frac{10 lbm}{s}\right)\left(32.2 ft/s^2\right)}\left(\frac{32.2 lbm\, ft}{lbf\, s^2}\right) = 185 s$$

SO LIKELY A SOLID OR MONOPROPELLANT LIQUID ROCKET

Communication & Instructional Continuity

In this class, the official mode of communication is through Canvas/UAH email. Students can expect a response from the instructor within a 24/48 hour timeframe. In the event a regular scheduled course is unexpectedly interrupted, course requirements, due dates, and grading policy are subject to change when necessitated by revised course delivery, semester calendar, or other instances. Information about changes in this case can be obtained from the Canvas course webpage or by contacting me.

If our regular scheduled class meeting is interrupted or the campus should unexpectedly close, students should immediately log onto Canvas and read any course announcements. Students are encouraged to continue the readings and other assignments as outlined on the course syllabus until otherwise advised. Any student who does not could fall behind in the course.

Course Conduct

All students must treat others with civility and respect and conduct themselves in a way that does not unreasonably interfere with the opportunity of other students to learn. All communication between student/instructor and between student/student should be respectful and professional.

Academic Honesty

Your written assignments and examinations must be your own work. Academic misconduct will not be tolerated. Examples of unacceptable behavior include plagiarism/use of prior work/use of Chegg and other online problem-solving sites/etc. To ensure that you are aware of what is considered academic misconduct, you should review carefully the definitions and examples provided in the Student Handbook. If you have questions in this regard, please contact me without delay.

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Discussion of Concerns

If you have difficulties or concerns related to this course, your first action should be to discuss them with your instructor. If such a discussion fails to resolve your difficulties, you should contact the MAE Department Chairperson, Dr. Keith Hollingsworth at keith.hollingsworth@uah.edu.

Class Schedule

Date	Module	Book Sections	Quiz #	Q Due	HW	HW Due
1/9	Module 1 - Fundamental Concepts	Chapter 1,2,3,4	1	1/14	HW01	1/18
1/11	Module 1 - Fundamental Concepts	Chapter 1,2,3,4				
1/16	No Class					
1/18	Module 2 - Hybrid Rocket Engines	Chapter 11.1 - 3	2A	1/21	HW02A	1/24
1/23	Module 2 - Hybrid Rocket Engines	Chapter 11.4 - 7	2B	1/28	HW2B	1/31
1/25	Module 2 - Hybrid Rocket Engines	Examples				
1/30	Module 3 - Combustion and Thermo.	5.1, 5.2, 5.3	3A	2/4	HW03A	2/7
2/1	Module 3 - Combustion and Thermo.	5.4				
2/6	Module 3 - Combustion and Thermo.	5.5, 5.6	3B	2/11	HW03B	2/14
2/8	Module 3 - Combustion and Thermo.	Examples				
2/13	Module 4 - Heat Trans. in Chem. Rockets	6.1, 6.2, 6.3	4A	2/18	HW04	2/28
2/15	Module 4 - Heat Trans. in Chem. Rockets	6.4, 6.5				
2/20	EXAM 1 - Modules 1, 2, 3		8A	2/25	PR-A	2/28
2/22	Exam Review/ Introduction of Project					
2/27	Module 5 - Liquid Rocket Engines	8.1 - 4	5	3/4	HW05	3/7
3/1	Module 5 - Liquid Rocket Engines	8.5 - .9				
3/6	Module 6 - Liquid Rocket Propellants	9.1 - 9.4	6	3/11	HW06	3/21
3/8	Module 6 - Liquid Rocket Propellants	9.5 - 9.8				
3/13	Spring Break					
3/15	Spring Break					
3/20	Module 8 - Class Project	Mat. Provided	8B	3/25	PR-B	3/29
3/22	Module 8 - Class Project	Mat. Provided				
3/27	EXAM 2 - Modules 4,5, 6					
3/29	Exam Review and Project Discussion				PR-C	4/4
4/3	Module 8 - Class Project	Mat. Provided				
4/5	Module 8 - Class Project	Mat. Provided				
4/10	Module 7 Turbomachinery/Comb. Instab.	Chapter 10	7	4/18	PR-D	4/11
4/12	Module 7 Turbomachinery/Comb. Instab.	Chapter 11				
4/17	Module 8 - Class Project//Course Summary	Mat. Provided				
4/19	Module 8 - Class Project	Mat. Provided				
4/26	Final Exam - Oral Presen, - 8:00 - 10:30					

The table below shows the homework assignment schedule. Each assignment sheet will prove the special problems developed for the module.

Module	Book Problems	Special Problems
1	2.6, 3.8, 4.24, 4.30	SP01
2A	11.3, 11.7	SP02A
2B	11.4, 11.5, 11.6	SP02B
3A	5.4, 5.16	SP03A
3B	5.9, 5.11	SP03B
4	6.4, 6.7	SP04
5	8.2, 8.13, 8.14	SP05
6	None	SP06
7	None	SP07
PR-A	Program Plan	
PR-B	Status Report	
PR-C	Status Report	
PR-D	Draft Report	

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

2023 SPRING CALENDAR

Disclaimer: UAH reserves the right to change, without notice, academic dates and related events.

JANUARY

S	M	T	W	Th	F	S
1	2 (1)	3	4	5	6	7
8	9 (2)	10	11	12	13	14
15	16 (3)	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

FEBRUARY

S	M	T	W	Th	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28				

MARCH

S	M	T	W	Th	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13 (M)	14 (T)	15 (W)	16 (Th)	17 (F)	18
19	20 (S)	21	22	23	24	25
26	27	28	29	30	31	

APRIL

S	M	T	W	Th	F	S
						1
2	3	4 (E)	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24 (E)	25 (E)	26 (E)	27 (E)	28 (E)	29
30						

MAY

S	M	T	W	Th	F	S
	1	2	3	4 (E)	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29 (M)	30	31			

SESSION	(1) FULL SEMESTER	(SP1) 7 WEEK	(SP2) 7 WEEK	(SP4) 10 WEEK	(SP5) 10 WEEK	(SP6) 5 WEEK	(SP7) 9 WEEK	(SP8) 5 WEEK
CLASSES BEGIN	Jan 9	Jan 9	Feb 28	Jan 9	Feb 13	Jan 9	Feb 13	Mar 28
DEADLINE TO ADD/DROP CLASS WITH REFUND	Jan 17	Jan 12	Mar 3	Jan 17	Feb 20	Jan 11	Feb 15	Mar 28
				NO REFUND AFTER THIS DATE				
DEADLINE FILE FOR PASS/FAIL	Jan 30	Jan 23	Mar 20	Jan 23	Feb 24	Jan 13	Feb 17	Mar 30
CHANGE CREDIT TO AUDIT	Feb 6	Jan 30	Mar 27	Jan 30	Mar 3	Jan 23	Feb 24	Apr 7
DEADLINE TO WITHDRAW	Apr 21	Feb 27	April 21	Mar 27	Apr 21	Feb 10	Mar 23	Apr 21
DEADLINE COURSE FORGIVENESS/ REPEAT	Apr 21	Feb 27	Apr 21	Mar 27	Apr 21	Feb 10	Mar 23	Apr 21
LAST CLASS	Apr 21	Feb 27	Apr 28	Mar 27	Apr 28	Feb 10	Mar 23	Apr 28
FINAL EXAMS	Apr 24 – 28	Feb 27	Apr 28	Mar 27	Apr 28	Feb 10	Mar 23	Apr 28
GRADING PERIOD	Apr 21 – May 3	Feb 27 – Mar 2	Apr 21 – May 3	Mar 27 – 30	Apr 21 – May 3	Feb 10 – 15	Mar 23 – 28	Apr 21 – May 3

Tuition Due Jan 9 for all Sessions
Deadline to Remedy an "I" grade from previous semester is April 28.

B	Classes Begin	H	Honors Day	( )	Staff Holidays
C	Commencement	L	Last Day of Classes	R	Registration, Priority
E	Examinations	N	No Classes	SD	Study Day

FINAL EXAMINATION SCHEDULE

CLASSES MEET		EXAM PERIOD
	April 24, Monday	
MWF	8:00 am to 8:55 am	8:00 am to 10:30 am
MW	8:00 am to 9:20 am	8:00 am to 10:30 am
All MA 113 & MA 171 Sections		11:30 am to 2:00 pm
MWF	1:00 pm to 1:55 pm	3:00 pm to 5:30 pm
MW	1:00 pm to 2:20 pm	3:00 pm to 5:30 pm
MW	6:00 pm to 7:20 pm	6:30 pm to 9:00 pm
MWF	6:00 pm to 6:55 pm	6:30 pm to 9:00 pm
M only	Evening only classes	Class
	April 25, Tuesday	
TR	8:00 am to 9:20 am	8:00 am to 10:30 am
TR	11:20 am to 12:40 pm	11:30 am to 2:00 pm
TR	2:40 pm to 4:00 pm	3:00 pm to 5:30 pm
TR	6:00 pm to 7:20 pm	6:30 pm to 9:00 pm
T only	Evening only classes	Class
	April 26, Wednesday	
MWF	9:40 am to 10:35 am	8:00 am to 10:30 am
MW	9:40 am to 11:00 am	8:00 am to 10:30 am
MWF	2:40 pm to 3:35 pm	3:00 pm to 5:30 pm
MW	2:40 pm to 4:00 pm	3:00 pm to 5:30 pm
MW	7:40 pm to 9:00 pm	6:30 pm to 9:00 pm
MWF	7:40 pm to 8:35 pm	6:30 pm to 9:00 pm
W only	Evening only classes	Class
	April 27, Thursday	
TR	9:40 am to 11:00 am	8:00 am to 10:30 am
TR	1:00 pm to 2:20 pm	11:30 am to 2:00 pm
TR	4:20 pm to 5:40 pm	3:00 pm to 5:30 pm
TR	7:40 pm to 9:00 pm	6:30 pm to 9:00 pm
R(TH) only	Evening only classes	Class
	April 28, Friday	
MWF	11:20 am to 12:15 pm	11:30 am to 2:00 pm
MW	11:20 am to 12:40 pm	11:30 am to 2:00 pm
MW	4:20 pm to 5:40 pm	3:00 pm to 5:30 pm
MWF	4:20 pm to 5:15 pm	3:00 pm to 5:30 pm
F only	Evening only classes	Class

Note: Absences from a scheduled final examination without previous arrangements with the course instructor (except in extenuating circumstances) will be classified as unexcused, and a failing grade (F) in the course will be assigned. For further information, refer to the UAH Catalog. No deviation is permitted from the announced Final Examination Schedule. A student with three exams scheduled in one day has the right to have the middle exam rescheduled by mutual agreement between student and instructor and must be agreed upon by the end of the final week of classes. Students are encouraged to make arrangements early with the faculty member.

07/25/22

University Information.

Disability Statement

The University of Alabama in Huntsville will make reasonable accommodations for students with documented disabilities. If you need support or assistance due to a disability, you may be eligible for academic accommodations. Apply here or contact Disability Support Services (256.824.1997 or Wilson Hall 128) as soon as possible to coordinate accommodations.

Pertinent UAH Policies

- UAH Student Handbook
- Academic Misconduct Policy
- Complete listing of UAH Policies and Procedures

Campus Resources

The University of Alabama in Huntsville offers a range of student services to enhance the experience of students.

- Academic Support Services—ASAP, Student Success Center, Tutoring, PASS, Academic Support Centers by College
- Student Support Services—Counseling Center, Disability Support Services, Student Health Services, Office of International Services, Multicultural Affairs, etc.
- UAlert—Sign up for UAH's emergency notification system to receive urgent messages from the university
- Registrar's Office—Academic Calendars, Course Registration, Student Records, Commencement
- M. Louis Salmon Library—Printed and Online Resources, Reference Services, Group Study Rooms, AV Resources, Printing
- Office of Diversity, Equity, and Inclusion—Anti-racism resources, LGBTQ resources, lactation rooms, name change requests, internet access assistance, Title IX
- Canvas Support—Call 844-219-5802 to report an issue with Canvas.
- OIT Help Desk—For technical support, contact the OIT Help Desk (helpdesk@uah.edu; 256.824.3333)

NOTE: When submitting a support ticket include your name, your class, the element/assignment being affected, and a detailed description of the issue. Providing a screenshot is often very helpful in diagnosing an issue.

Important Dates

Review the semester dates and deadlines and the academic calendar.

Subject to Change

Every effort is made to follow the guidelines in the syllabus; however, if needed, the syllabus will be amended. You will be notified if changes are made.

Appendix – MAE 640 Module Learning Objectives

Module 01	**Fundamental Concepts**
Objective 01-A	Students will be able to demonstrate basic knowledge of propulsion terminology and the results of the last class project
Objective 01-B	Students will be able to calculate the performance of an over-expanded nozzle that has separated flow
Objective 01-C	Students will be able to derive the thrust and exit velocity equations for a converging-diverging nozzle from the conservation of momentum and conservation of energy equations.
Module 02	**Hybrid Rocket Engines**
Objective 02-A	Students will be able to correctly define and describe fundamental concepts, advantages, and performance parameters of hybrid rockets engines.
Objective 02-B	Students will be able to perform calculations of basic performance parameters and internal ballistics.
Objective 02-C	Students will apply concepts using a computer program to describe time-dependent internal ballistics and thrust
Module 03	**Combustion and Thermochemistry**
Objective 03-A	Students will be able to correctly define and describe fundamental concepts to predict the composition and temperatures of combustion gases.
Objective 03-B	Students will be able to perform calculations of adiabatic combustion properties for no-dissociation and limited-dissociation assumptions.
Objective 03-C	Students will apply concepts using a computer program to calculate combustion gas properties and propulsion properties for typical rocket propellants.
Module 04	**Heat Transfer in Chemical Rockets**
Objective 04-A	Students will be able to correctly define and describe fundamental concepts used in the heat transfer analysis of Chemical Rockets.
Objective 04-B	Students will be able to perform calculations of heat transfer for the internal flow of gases in a converging-diverging nozzle
Objective 04-C	Students will apply concepts using a computer program to calculate combustion gas properties related to heat transfer in a rocket nozzle.
Module 05	**Liquid Rocket Engines**
Objective 05-A	Students will be able to define key terms for liquid rocket engine systems
Objective 05-B	Students will be able to calculate combustion chamber sizes, engine performance, and tank sizes for liquid rocket systems
Objective 05-C	Students will be able to use a computer code to predict the thermochemical properties of a liquid rocket engine

Module 06	**Liquid Rocket Propellants**
Objective 06-A	Students will be able to define key terms for liquid rocket engine propellants.
Objective 06-B	Students will be able to describe energetic, kinetic, and utilization qualities of liquid propellants
Objective 06-C	Students will be able to use a computer code to calculate the chamber temperature, bulk density, characteristic velocity, and specific impulse at least 10 different liquid rocket propellants.
Module 7	**Turbomachinery and Combustion Instability**
Objective 07-A	Students will be able to identify the major elements of rocket turbopumps
Objective 07-B	Students will be able to describe engineering concepts related to pump design, inducer design, impeller design, pump operating envelope,, shafts bearings and seals, and rotordynamics
Objective 07-C	Students will be able to identify the classifications and phenomenology of combustion instability in rocket engines
Objective 07-D	Student will be able to describe analysis approaches for low- frequency and high-frequency instability, and calculate acoustic modes.
Module 08	**Class Project**
Objective 08-A	Students will summarize the historical development of ramjet engines and solid fuels based on reading 10 papers
Objective 08-B	Students will apply propulsion principals to model and simulate the operation of a solid fuel ramjet operating in flight and to calculate the inlet airflow, thermochemistry, internal ballistics, thrust and trajectory for a baseline system.
Objective 08-C	Students will design a ramjet system to maximize the total impulse (range) subject to mission design constraints by selecting propellant formulations, grain configurations, and nozzle dimensions and/or compare the relative performance of alternative propulsion systems to meet the same mission requirements