Proposed Revised Graduate Course

Course Title

Theory and Performance of Propellants and Explosives I

Program

Mechanical Engineering

Proposed Course No.

ME505

Catalog Description

The class covers the treatment of the physical and chemical theoretical principles which govern the characteristics and performance of propellants and explosives. This will include the theories to explain stability, sensitivity, combustion, detonation, initiation, power, thermochemical and thermodynamic calculations to enable performance to be predicted. Select topics in shock physics will be presented.

Course Objectives

The course is designed for students who will work in munitions systems utilizing explosives and/or propellants. This course will provide the students with an understanding of the materials, technologies, and science behind munition systems' explosive and propellant components.

List of Course Outcomes

The student will be able to:

- Determine graphically and compute numerically the state properties resulting from a high speed collision.
- Compute the Chapman Jouget conditions at the detonation front.
- Compute the pressure caused by a detonation wave impacting a material.
- Identify the common chemical structures of explosives and propellants.
- Identify the common processes for explosive synthesis.
- Use the burning rate equation to describe the functioning and malfunctioning of propellants.
- Explain the meaning of the various UN classifications of explosives.
- Explain the difference between primary and secondary explosives.
- Sketch and explain the components of an explosive train.
- Design a test that ensures usable data for statistical analysis of reliability.
- Calculate the reliability of initiation from data based on Bruceton analysis.
- Determine if reliable initiation of an explosive is achieved based on energy fluence.
- Calculate the critical temperature for energetics materials based upon size.
- Describe the basic test methods for detonation testing.

Prerequisites

Acceptance into Stevens masters program.

Cross-listings

N/A

Grading Percentages

Homework	☒ _20%	Class work	☐ ___%	Projects	☒ _20%	Quizzes	☐ ___%
Mid-term	☒ _20%	Final	☒ _30%	Other	☒ _10% Specify: _Attendance_____		

Number of Credits

3 credits	☒	Other	☐ Specify: ___

For Graduate Credit toward Degree or Certificate

Yes	☒	No	☐	Other	☐ Specify: _____

Textbooks or References

- Meyers, Marc A., Dynamic Behavior of Materials, John Wiley & Sons, 1994.
- Cooper, Paul W., Explosives Engineering, Wiley-VCH, 1996.

Mode of Delivery

In-class	☒	Online	☐	Modules	☐
Other	☐ Specify: _____Online may be used occasionally_____				

Department Ownership

Department of Mechanical Engineering

Syllabus

	Topic(s)	Reading(s)	Class Exercises (Optional)	Homework
1	Review of Thermo-dynamics and Speed of Sound			Research a technical journal article for the class assignment.
2	Shock waves in solids I	Cooper chapters 16-19 Meyer chapter 4	A shock physics explanation of Newton's Cradle	Write a MATLAB or Excel program to compute state properties resulting from a high speed collision. Use program and graphical methods for an assigned collision and compare results.
3	Detonation physics	Meyer chapter 10, Cooper chapter 20, 21		Compute state properties of a detonating explosive. Compute pressure imposed on a solid in contact with a detonating explosive.
4	Black powder	None		Essay questions on black powder: its replacement as a propellant and why it is still used as an igniter.
5	Chemical structure of energetics	Cooper chapter 3		Essay questions of explosive stability and chemical structure.
6	The nitration era	None		Essay questions on chemical impurities and acids used in synthesis of explosives.
7	Pyrotechnics	None		Take-home Midterm exam
8	Propellant burning Midterm review	None	Student presentations	Essay questions of rocket motor and gun propellant construction in relation to burning.
9	Classification of energetics	Cooper chapter 22	Student presentations	Essay questions on erratic propellant burning and explosive additives.
10	Energetics Performance Testing	None	Student presentations	Essay question on methods to measure detonation velocity. Determine shape of a detonation wave when provided a streak photograph of a multi-profile streak technique.
11	Initiation	Cooper chapters 23-24	Student presentations	Compute energy fluence for a flyer plate impacting an explosive, use this figure to determine if initiation occurs.
12	Energetics Safety Testing	None	Student presentations	Essay question on safety
13	Statistics for Binomial results	None	Run an analysis from data generated in class	From provided data, determine reliability of initiation using Bruceton analysis.
14	Introduction to warheads	Cooper chapter 30		Essay questions on selection of energetics for to match required results
15	Thermal initiation and critical temperature-size relations	None		Determine critical size of an explosive that will lead to thermal cook-off. Essay question of thermal hot spots and voids. Take-home final exam
16	Final review	None		Final exam collected.

For the class project, each student individually will select a journal article in a subject related to the class and obtain instructor approval. A presentation is given to the class. The presentation will include an explanation of the paper, a critical review identifying the unique aspects of the research and identifying errors. The student is expected to read and report on important citations from the article and propose a reasonable next stage for the research (30 min.).

Homework is assigned each week with the following grading system:

- Correct 100%
- Incorrect but fair attempt 100%
- Incomplete but with a clear explanation of your problems understanding the assignment, 100%
- Otherwise 0%