

**Fusion Technology**  
**NE 485/NE 515**  
**Fall 2023**

**Lecture:** MWF 12:00 – 12:50 PM; room

**Designation (NE):** Nuclear Engineering Elective

**2023-2024 Catalog:** NE 485. *Fusion Technology*. (3)

The technology of fusion reactor systems including basic magnetic and inertial confinement physics, system designs, material considerations, shielding, blanket designs, fuel cycle, plant operations, magnets, and ICF drivers.

**Prerequisite:** An undergraduate course in Differential Equations, such as MATH 316

**Restriction:** At least Junior standing in the School of Engineering.

**Instructor:** Eric Lang  
Phone: 277-0772, Office: 1100 Ferris, Email: ejlang2@unm.edu

**Office Hours:** Open Door

**Text:** A.A. Harms, K.F. Schoepf, G.H. Miley, and D.R. Kingdon, *Principles of Fusion Energy*, World Scientific Publishing, 2000. ISBN 978-981-238-033-3.

**Class web page:** Canvas. Will be posted and up and running soon.

**Other References:**

1. Friedberg, *Plasma Physics and Controlled Fusion*
1. T.J. Dolan, *Magnetic Fusion Technology*
2. R.A. Gross, *Fusion Energy*
3. S. Artzeni and J. Meyer-ter-Vehn, *The Physics of Inertial Fusion*
4. F.F. Chen, *Introduction to Plasma Physics and Controlled Fusion*

**Course Objective:** To gain a strong foundation in the fundamental concepts of nuclear fusion technology

**Topics:**

1. Fusion Energy Basics
  - a. Introduction to Fusion and Fusion Design
  - b. Fusion Reactions and Reaction Rates
  - c. Plasma Pressure and Reaction Rate Limits
  - d. Radiation Losses, the Ideal Ignition Temperature, the Lawson Criterion
2. Charged Particle Motion and Plasma Confinement
  - a. Single Particle Motion in Magnetic Fields and Collisions
  - b. Magnetic Mirror Confinement and Tandem Mirrors
  - c. Tokamak Confinement and Design
  - d. Inertial Confinement Physics and Design
  - e. Magneto-Inertial Fusion (MIF) and Alternate Concepts
3. Fusion Experiments and Diagnostics
4. Fusion Reactor Systems
  - a. Reactor Blankets
  - b. Tritium Cycle
  - c. Superconducting Magnets
  - d. Material Issues
5. Environmental Issues

## **Learning Outcomes:**

1. Describe the general features of a “fusion reactor”, the potential advantages of fusion and the technological issues that still must be overcome to make fusion a viable energy source.
2. Explain and sketch the differences between magnetic and inertial confinement approaches to controlled fusion.
3. Calculate ideal ignition temperature and the Lawson criterion and do simple problems applying these concepts.
4. Perform simple fusion reaction rate, plasma pressure, radiation loss, magnetic mirror, Tokamak physics, and ICF pellet calculations.
5. Conceptually and computationally describe the motion of charged particles in electric and magnetic fields.
6. Sketch the essential components of a fusion reactor.
7. Explain the outstanding materials issues facing the development of a fusion reactor.

## **Grading**

Homework 40%, midterm exam 15%, final exam 20%, term project 15%, oral quiz: 5%, group activity participation: 5% Graduate students will be required to give an oral presentation of their project (details TBA).

## **Homework**

Homework assignments will be given approximately biweekly. Late homeworks will receive reduced credit unless prior arrangements have been made. Homework will be due by the end of the business day (5pm Mountain Time) either in person to me, or in my mailbox. The reduction will be 10% per day, up to a maximum of 50% reduction. Some homeworks will involve computer solutions and plotting, so you will need access to software with math and plotting functions, such as MATLAB, IDL, Mathematica, etc.

Students will be given one (1) Homework Get Out of Jail Free Pass, giving them the opportunity to delay turning in a homework assignment for up to three (3) days.

## **Final Exam** Time TBD

### **Accommodation Statement:**

Accessibility Services (Mesa Vista Hall 2021, 277-3506) provides academic support to students who have disabilities. If you think you need alternative accessible formats for undertaking and completing coursework, you should contact this service right away to assure your needs are met in a timely manner. If you need local assistance in contacting Accessibility Services, see the Bachelor and Graduate Programs office.

### **Academic Integrity:**

The University of New Mexico believes that academic honesty is a foundation principle for personal and academic development. All University policies regarding academic honesty apply to this course. Academic dishonesty includes, but is not limited to, dishonesty in quizzes or assignments; claiming credit for work not done or done by others; hindering the academic work of other students; misrepresenting academic or professional qualifications within or outside the university; and nondisclosure or misrepresentation in filling out applications or other university records. All students are expected to maintain the highest standards of honesty and integrity in academic and professional matters. The University reserves the right to take disciplinary action, including dismissal, against any student found responsible for academic dishonesty or failing to meet the standards. Any student judged to engage in academic dishonesty may receive a reduced or failing grade for work in question and/or the course. The University's full statement on academic honesty and the consequences for failure to comply is available in the college catalog and in the Pathfinder.

### **Title IX:**

In an effort to meet obligations under Title IX, UNM faculty, Teaching Assistants, and Graduate Assistants are considered “responsible employees by the department of Education (see pg 15 - <http://www2.ed.gov/about/offices/list/ocr/docs/qa-201404-title-ix.pdf>). This designation requires that any report of gender discrimination which includes sexual harassment, sexual misconduct and sexual violence made to a faculty member, TA, or GA must be reported to the Title IX Coordinator at the Office of Equal Opportunity (oeo.unm.edu). For more information on the campus policy regarding sexual misconduct, see: <https://policy.unm.edu/university-policies/2000/2740.html>.

**COVID-19 Health and Awareness:**

UNM is a mask friendly, but not a mask required, community. To be registered or employed at UNM, Students, faculty, and staff must all meet UNM's Administrative Mandate on Required COVID-19 vaccination. If you are experiencing COVID-19 symptoms, please do not come to class. If you have a positive COVID-19 test, please stay home for five days and isolate yourself from others, per the Centers for Disease Control (CDC) guidelines. If you do need to stay home, please communicate with me at (505) 277-0772 or by email; I can work with you to provide alternatives for course participation and completion. UNM faculty and staff know that these are challenging times. Please let me, an advisor, or another UNM staff member know that you need support so that we can connect you to the right resources. Please be aware that UNM will publish information on websites and email about any changes to our public health status and community response.

**Support:**

Student Health and Counseling (SHAC) at (505) 277-3136. If you are having active respiratory symptoms (e.g., fever, cough, sore throat, etc.) AND need testing for COVID-19; OR If you recently tested positive and may need oral treatment, call SHAC. LoboRESPECT Advocacy Center (505) 277-2911 can offer help with contacting faculty and managing challenges that impact your UNM experience.

**Connecting to Campus and Finding Support:**

UNM has many resources and centers to help you thrive, including opportunities to get involved, mental health resources, academic support including tutoring, resource centers for people like you, free food at Lobo Food Pantry, and jobs on campus. Your advisor, staff at the resource centers and Dean of Students, and I can help you find the right opportunities for you.

**Respectful and Responsible Learning:**

We all have shared responsibility for ensuring that learning occurs safely, honestly, and equitably. Submitting material as your own work that has been generated on a website, in a publication, by an artificial intelligence algorithm, by another person, or by breaking the rules of an assignment constitutes academic dishonesty. It is a student code of conduct violation that can lead to a disciplinary procedure. Please ask me for help in finding the resources you need to be successful in this course. I can help you use study resources responsibly and effectively. Off-campus paper writing services, problem-checkers and services, websites, and AIs can be incorrect or misleading. Learning the course material depends on completing and submitting your own work. UNM preserves and protects the integrity of the academic community through multiple policies including policies on student grievances (Faculty Handbook D175 and D176), academic dishonesty (FH D100), and respectful campus (FH CO9). These are in the Student Pathfinder (<https://pathfinder.unm.edu>) and the Faculty Handbook (<https://handbook.unm.edu>).

**Library and Tutorial Services** UNM-Main campus provides many library services and some tutorial services for distance students. For library services, go to <http://www.unm.edu/libraries/> to link to a specific library or to contact a librarian. For tutorial services, go to <http://caps.unm.edu/online> to explore UNM's online services.

**Weather Policy:** In the event of severe weather conditions UNM may close. Please call 277-SNOW to check UNM's status during questionable weather conditions.

## Course Schedule

The Course Schedule is subject to change. Minor changes will be announced in class, major ones provided in writing.

28-Aug	Introduction and TGA1	
30-Aug	Designs Overview	IT Chapman Paper
1-Sep	Cross-sections	
6-Sep	Cross-sections/power balance	
8-Sep	Power Balance	
11-Sep	Power Balance/TGA2 - Eric gone	
13-Sep	Power Balance	
15-Sep	Charged Particle Motion	
18-Sep	Charged Particle Motion	
20-Sep	Charged Particle Motion	
22-Sep	Open Confinement	
25-Sep	Closed Confinement	
27-Sep	Closed Confinement/TGA3	
29-Sep	Midterm 1	
2-Oct	Tokamaks	Itoh
4-Oct	Tokamaks	Dickinson
6-Oct	Tokamaks	
9-Oct	MHD	
11-Oct	MHD	
13-Oct	Transport	
16-Oct	Transport	
18-Oct	Heating and Current Drive	Hemsworth
20-Oct	Heating and Current Drive	ECRH
23-Oct	Stellarators	Helander
25-Oct	Fission-fusion Hybrids/TGA4	
27-Oct	Reactor Systems	
30-Oct	Diagnostics	
1-Nov	Diagnostics	Cosley
3-Nov	Tritium Fuel Cycle	T Tanabe, Abdou
6-Nov	Tritium Fuel Cycle	Forsberg
8-Nov	Midterm 2	
10-Nov	Materials Issues	J Linke, W Fuzz
13-Nov	Materials Issues	Bruzzzone, Whyte
15-Nov	Materials Issues	Fiflis
17-Nov	Materials Issues	Winter
20-Nov	Materials Issues	Abdou
22-Nov	Environmental Issues	N Taylor
27-Nov	ICF	Hurricane
29-Nov	ICF	Chapman Paper
1-Dec	ICF	
4-Dec	Presentations	
6-Dec	Presentations	
8-Dec	Semester Review	
12-Dec	Final Exam	

**n.b.** I want you all to succeed in the course.