NUCL 460- Introduction to Controlled Thermonuclear Fusion
Spring 2024 8 January 2024

Instructor: C. K. Choi choi@purdue.edu
LMBS 5246 (Gateway Building, Room 5246) (765) 494-6789
Schedule: Lecture Course MWF 1:30 – 2:20 PM @GRIS 126

Course Outline: Fusion energy is the energy of the future. This course is designed for advanced undergraduate students or beginning graduate students in engineering or physical sciences to study the fundamentals and an overview of the thermonuclear fusion energy researches in the U. S. and abroad.

Course Syllabus:

1. Reviews of fusion vs. fission and survey of the world energy resources.
2. Introduction to fusion problems: Thermonuclear reactions, reaction rates, and power density.
3. Introduction to basic plasma physics, Coulomb collisions, and review of the Maxwell's equations.
4. Plasma heating and the requirements for fusion ignition.
5. Energy balance: Radiation losses and impurity control, energy breakeven Lawson criterion.
6. Plasma confinement: Toroidal and linear fusion reactor devices.
7. Stability configurations: Plasma equilibrium and the control of plasma instabilities.
8. Energy conversion: direct- and indirect-energy conversion to electric power production.
9. Reviews of current magnetic-confinement fusion energy (MFE) to fusion reactor operations; concepts such as tokamak (e.g., ITER), mirror, field-reversed compact torus, pinch, bumpy torus, mirror cusp, spheromak, spherical tokamak, stellarator (e.g., Wendelstein 7X), etc.
10. Current inertial-confinement fusion energy (IFE) approaches to fusion reactor operations; lasers (e.g., National Ignition Facility, NIF), heavy- and light-ion beams, magnetized target driver concepts, and the NIF/IFE target design characteristics.

Textbooks:

Required: **F. Chen**, *Introduction to Plasma Physics and Controlled Fusion,* 3rd/ed., Springer Nature/Science (2016). ISBN: 978-3-319-22308-7. www.link.springer.com → Search & download;
T. Dolan, *Fusion Research,* Vol. I (Principles), Pergamon Press (1982). ISBN: 0-08-025566-3. https://uofi.box.com/s/gixqw1wspu6uokws6d0m [Free down loadable];

Recommended: **U. Inan and M. Golkowski**, *Principles of Plasma Physics for Engineers and Scientists*, Cambridge Univ. Press (2011). ISBN: 978-0-521-19372-6;
M. Kikuchi, et al. (Ed.), *Fusion Physics*, IAEA (2012). ISBN:978-92-0-130410-0 [Free access];
J. Bobin, *Controlled Thermonuclear Fusion*, World Scientific (2014). ISBN: 978-981-4590-68-6;
E. Morse, *Nuclear Fusion*, Springer Nature Science (2018), ISBN: 978-3-319-98170-3;
J. Parisi & **J. Ball**, *The Future of Fusion Energy*, World Scientific (2019).ISBN:978-1-78634-749-7.

Instructor: Office Hours: MWF 2:45 – 4:00 PM @LMBS 5246, or by Appointment

Course Grading: Homework (25%), Midterm Exams (3) (45%), and Final Exam (30%);
$85\% \le A \le 100\%$, $70\% \le B < 85\%$, $55\% \le C < 70\%$, $40\% \le D < 55\%$,
and not passing below 40%; unexcused absences over 2 weeks = not passing.