# Introduction to Plasma Physics

(409.307A, 3 credits)

1st Semester of 2019

Department of Nuclear Engineering

**Classroom:** Rm 32-106

**Time:** Tuesday, Thursday 9:30 - 10:45

**Instructor:** Prof. Dr. Yong-Su Na (Rm 32-206, x 7204, ysna@snu.ac.kr)

**T.A.:** Chae-Beom Lim (Rm 30-103, x 8336, dlacoqja1029@snu.ac.kr)

**Overview:**

All gases become ionised at sufficiently high temperature creating what has been called a "fourth state of matter". This new state is known as plasma. A plasma can be defined as a gas of charged and neutral particles exhibiting collective behavior. It has been estimated that more than 99% of the universe is in the plasma state. On the earth, plasmas are much less common. Lightning is a familiar natural manifestation and fluorescent lights are an everyday practical application of plasmas. The first understanding of plasmas came from gas discharge tubes in the early 1900's. This was followed in the 1920's by an interest in electron behavior in vacuum tubes which was continued until the advent of transistors in the 1960's. The majority of plasma studies since 1960 have been motivated by the desire to produce electricity with a controlled thermonuclear reaction - in a sense to mimic the sun. Since the late 1980's there has been an increasing interest in and industrial use of plasma processing of materials.

This course introduces basic properties and physical phenomena of high- and low-temperature plasmas. It focuses on description of plasma characteristics by charged particle motions, kinetic and fluid theory which deals with waves, equilibrium, stability and transport of plasmas. Basic mechanism of plasma production is also addressed.

**Purpose:**

1) Develop an understanding of ways to describe a plasma
2) Explore applications of plasma physics

**Application:** Thermonuclear Fusion
Plasma Processing
Astrophysics

**Prerequisite:**

- Engineering Mathematics 1, 2, Introduction to Plasma Electrodynamics 1, 2
- Recommended: Thermal Physics, Fluid Mechanics

**Textbook:**

- F.F. Chen, "Introduction to Plasma Physics and Controlled Fusion, Volume 1: Plasma Physics", 2nd Edition, Springer (2006)
- 스가이 히데오, 오에 카즈유키 (김곤호, 양성채 편역), "플라즈마 일렉트로닉스", 교학사 (2006)

**References:**

- R.J. Goldston and P.H. Rutherford, "Introduction to Plasma Physics", Taylor & Francis (1995)
- J.A. Bittencourt, "Fundamentals of Plasma Physics", 3rd Edition, Springer (2004)
- J. Feidberg, "Plasma Physics and Fusion Energy", Cambridge (2007)

**Evaluation Elements:**

- Attendance (10%), Homework (10%), Quiz (20%)
- Midterm Exam (30%), Final Exam (30%)

**Class Schedule**

| Week | Contents |
|---|---|
| 1 (3.5, 7) | What is a Plasma? (Ch. 1) - Definition |
| 2 (3.12, 14) | Single Particle Motions I (Ch. 2) |
| 3 (3.19, 21) | Single Particle Motions II (Ch. 2) - Exercise |
| 4 (3.26, 28) | Rutherford Scattering, Kinetic Theory I |
| 5 (4.2, 4) | Kinetic Theory II (Ch. 7) |
| 6 | Midterm Exam |
| 7 (4.16, 18) | Fluid Theory I (Ch. 3) |
| 8 (4.23, 25) | Fluid Theory II (Ch. 5) |
| 9 (4.30, 5.2) | Fluid Theory III (Ch. 5) |
| 10 (5.7, 9) | Waves in Plasmas (Ch. 4) |
| 11 (5.14, 16) | Transport I |
| 12 (5.21, 23) | Transport II (Ch. 5) |
| 13 (5.28, 30) | Equilibrium and Stability I (Ch. 6) |
| 14 (6.4) | Equilibrium and Stability II (Ch. 6) |
| 15 (6.11, 13) | Plasma Breakdown |
| 15 | Final Exam |