Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

Expected Implementation in Academic Year	AY2025-2026
Semester/Trimester/Others (specify approx. Start/End date)	Semester 2
Course Author * Faculty proposing/revising the course	Qu Zhisong
Course Author Email	zhisong.qu@ntu.edu.sg
Course Title	Introduction to Plasma Physics
Course Code	PH3407
Academic Units	3
Contact Hours	39
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	PH2102 Electromagnetism and PH2103 Thermal Physics
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

Plasma, also known as the “fourth state of matter”, is common in the universe: more than 90% of the baryonic matter in the universe is believed to be in the plasma state. This course introduces the basic plasma physics: the concept of plasmas, the theories describing it, and some of its unique phenomena. You will be facilitated with some common problem-solving skills, both analytically and numerically. Finally, we will cover the applications in solar physics, astrophysics, nuclear fusion reactors, industry, and daily life.

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	Define a plasma, identify their appearance in various environments, and calculate their relevant parameters.
ILO 2	Describe charge particle motions in electromagnetic field, identify the invariants of motion, and compute the particle orbits.
ILO 3	Construct the fluid equations for plasmas and discuss the suitability of various assumptions.
ILO 4	Derive and solve the wave dispersion relationships of homogenous plasmas, estimate the wave frequencies, identify their relevancy and applications.
ILO 5	Illustrate how plasmas form equilibrium states, compute their profiles.
ILO 6	Explain the kinetic description of plasmas and the Vlasov equation, and construct the fluid equations from taking the moments. Explain and derive Landau damping.
ILO 7	Identify and distinguish the characteristics of Coulomb collisions and neutral collisions. Compute the plasma collision rate and the resistivity. Estimate the plasma diffusion rate and differentiate the transport regimes. Construct the plasma profile.
ILO 8	Discuss the concept of stability, determine if a plasma is stable or not, classify various types of instabilities, and compute their growth rate.
ILO 9	Illustrate the application of plasmas. Discuss the applicability of theories covered in the course.

Course Content

1. What is a plasma?

- Plasma frequency, Debye length, and quasi-neutrality
- Natural plasmas, laboratory plasmas, and their parameters

2. Single particle motion

- Guiding centre drift in uniform E and B fields
- Guiding centre drift in non-uniform and time-varying fields
- Adiabatic invariants

3. Fluid description of plasmas

- Derivation of the fluid equations
- Magnetohydrodynamics (MHD)

4. Plasma waves in homogenous media

- Linearisation of the fluid equations
- Waves in unmagnetized plasmas
- Waves in magnetised plasmas
- Alfvén waves

5. Plasma equilibrium

- MHD equilibrium
- Equilibrium in simple geometries, astrophysical objects, and fusion devices

6. Kinetic theory

- Plasma as a distribution function
- The Vlasov equation, fluid equation derivation revisit
- Landau damping

7. Collisions and transport

- Coulomb collisions, neutral collisions
- Plasma resistivity
- Diffusion and transport

8. Stability

- Rayleigh-Taylor instabilities
- Tearing instabilities, magnetic reconnections, solar flare
- Other important instabilities in natural and lab plasmas

9. Applications

- Solar and astrophysical plasmas, nuclear fusion reactors, industrial plasmas, etc

Reading and References (if applicable)

1. Chen, F. F. (2015). *Introduction to Plasma Physics and Controlled Fusion*. Springer International Publishing AG. ISBN: 9783319223087 (Full text available online in NTU library)
2. Choudhuri, A. R. (1998). *The physics of fluids and plasmas: an introduction for astrophysicists*. Cambridge University Press. ISBN: 9780521554879
3. Goldston, R. J. and Rutherford, P. H. (1995). *Introduction to plasma physics*. CRC Press. ISBN : 9781439822074 (Full text available online in NTU library)

NOTE: Reading list will be updated as and when necessary to be up-to-date.

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	What is a plasma?	1	Book 1, Chapter 1	In-person	Tutorial
2	Single particle motion	2	Book 1, Chapter 2	In-person	Tutorial, Wooclap
3	Single particle motion	2	Book 1, Chapter 2	In-person	Tutorial, Wooclap, Assignment
4	Plasma as fluids, magnetohydrodynamics	3	Book 1, Chapter 3	In-person	Tutorial, Wooclap
5	Waves in homogenous unmagnetized plasmas	4	Book 1, Chapter 4	In-person	Tutorial, Wooclap
6	Waves in homogenous magnetized plasmas	4	Book 1, Chapter 4	In-person	Tutorial, Wooclap, Assignment
7	Equilibrium	5	Book 1, Chapter 6	In-person	Mid-term test, Tutorial, Wooclap
8	Kinetic description of plasmas/ Landau damping	6	Book 1, Chapter 7	In-person	Tutorial, Wooclap
9	Landau damping	6	Book 1, Chapter 7	In-person	Tutorial, Wooclap, Assignment
10	Diffusion and transport	7	Book 1, Chapter 5	In-person	Tutorial, Wooclap
11	Diffusion and transport	7	Book 1, Chapter 5	In-person	Tutorial, Wooclap, Assignment
12	Stability	8	Book 1, Chapter 6	In-person	Tutorial, Wooclap
13	Applications	9	Book 1 Chapter 10	In-person	Tutorial, Wooclap

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Lectures	Applications will be introduced first to motivate the topic. The fundamental concepts and the theory will then be introduced and discussed. Finally, the concepts are utilized to further explain the application.
Tutorial	Review and discussion of key concepts from lectures with the lecturer and TA, by working through problems. The lecturer and TA will monitor and provide timely feedback.
Assignments	There will be 4 take-home written assignments mostly consisting of short answer questions. The assignments will consolidate the learning outcomes by providing you with a chance to practice your knowledge.
Mid-term test	Mid-term test is used to motivate and assess your understandings after the recess week.
Wooclap	Wooclap is used to promote deeper thinking and discussions during the class.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Description of Assessment Component	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Test/Quiz(Mid-term test)	1-5		20	Restricted-open-book exam.	Individual	Analytic	Multistructural
2	Continuous Assessment (CA): Assignment(Assignments)	All		20	Four take-home written assignments.	Individual	Analytic	Relational
3	Summative Assessment (EXAM): Final exam(Final examination)	All		55	Restricted-open-book exam.	Individual	Analytic	Relational
4	Continuous Assessment (CA): Class Participation(Wooclap)	All		5	9 out of 13 Wooclap participations to receive full marks.		Analytic	Multistructural

Description of Assessment Components (if applicable)

Formative Feedback

Formative feedback is given through discussion within tutorials. We will hold TA meetings regularly to discuss the progress and difficulty level of the course.

Feedback will be given during the class after each Wooclap session.

Feedback will be given after assignments and the mid-term test to highlight the common mistakes and misunderstandings.

Past exam questions will be made available.

You can contact the lecturer after class or via email for individual questions and feedback.

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level
Curiosity	Basic
Learning Agility	Intermediate
Problem Solving	Intermediate
Sense Making	Intermediate

Course Policy

Policy (Academic Integrity)

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values. As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

You are expected to complete all assigned pre-class readings and activities, attend all tutorial classes punctually and take all scheduled assignments and tests by due dates. You are expected to participate in all tutorial discussions and activities.

Policy (Absenteeism)

Absence from the mid-term without a valid reason will affect your overall course grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies.
If you are sick and unable to attend your class (particularly the mid-terms), you must:
1. Contact the lecturer to schedule an oral make-up exam within two weeks.
2. Submit the Medical Certificate* to administrator.
* The medical certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.

Policy (Others, if applicable)

Diversity and inclusion policy

Integrating a diverse set of experiences is important for a more comprehensive understanding of science.

It is our goal to create an inclusive and collaborative learning environment that supports a diversity of perspectives and learning experiences, and that honours your identities; including ethnicity, gender, socioeconomic status, sexual orientation, religion or ability.

To help accomplish this:
- If you are neuroatypical or neurodiverse, have dyslexia or ADHD (for example), or have a social anxiety disorder or social phobia;
- If you feel like your performance in the class is being impacted by your experiences outside of class;
- If something was said in class (by anyone, including the instructor) that made you feel uncomfortable;

Please speak to your teaching team, our school pastoral officer or a peer or senior (either in-person or via email) about how we can help facilitate your learning experience.

As a participant in course discussions, you should also strive to honour the diversity of your classmates. You can do this by: using preferred pronouns and names; being respectful of others opinions and actively making sure all voices are being heard; and refraining from the use of derogatory or demeaning speech or actions.

All members of the class are expected to adhere to the NTU anti-harassment policy. if you witness something that goes against this or have any other concerns, please speak to your instructors or a faculty member.