PHYS 2041 University Physics III
Introduction to Heat and Electromagnetism

(2022-23 1st term)

1. Course Description

This is an introductory calculus-based course which discusses the basic principles of thermodynamics and electromagnetism. The course assumes students to have a good background of HKDSE Physics (or equivalent) and calculus. This course is a core course for physics majors. Topics include: the laws of thermodynamics and the kinetic theory of gases; Coulomb's law, electric field and potential, Gauss' law, capacitance and dielectrics, current and resistance, DC circuits, magnetic fields, Ampere's law, Faraday's law, inductance, AC circuits, Maxwell's equations and electromagnetic waves.

2. Learning Outcomes

- Gain an understanding of the fundamental principles of thermodynamics and electromagnetism, within a formalism using vectors and elementary calculus;
- Acquire the ability to use some mathematical methods, such as vector algebra and calculus, and an appreciation of their roles and applications in thermodynamics and electromagnetism, and the be able to apply them to other courses;
- Build up a solid foundation of the necessary background for upper-level courses in electromagnetism and other physics courses in the curriculum;
- Gain a sense of relative importance of various physical quantities, and be able to make suitable approximations in mathematical derivations;
- Gain a coherent picture of how the descriptions of various physical phenomena are unified by the laws of thermodynamics and Maxwell's equations;
- Gain an appreciation of the importance of thermodynamics and electromagnetism in physics, as well as their applications in the modern world.

3. Learning Resources

Course Website

The course website (**blackboard.cuhk.edu.hk/**) has the following information and resources:

- Course materials: lecture notes, homework assignments and solution.
- A notice board for announcements of homework assignments and important events (e.g. examination).

Textbook

- ***HRW*****:** D. Halliday, R. Resnick, and J. Walker, *Principles of Physics*, 10th ed., John Wiley & Sons.
  Some of the homework problems will be taken from the textbook.
- D.J. Griffiths, *Introduction to Electrodynamics*, 3rd ed., Prentice Hall 1999.

Other References

- Feynman, Leighton and Sands, *The Feynman Lectures on Physics*, Book 2, 1979.
- H.D. Young and R.A. Freedman, *University Physics with Modern Physics*, 12th ed., Addison-Wesley
- P.M. Fishbane, S.G. Gasiorowicz, S.T. Thornton, *Physics for Scientists and Engineers with Modern Physics*, 3th ed., Pearson.

4. Course Content (Coverage: Chapter 18-33 of HRW)

	Topics	Contents	Ref. (HRW)
1.	Temperature, Heat, and the First Law of Thermodynamics	Temperature and the Zeroth law of thermodynamics, thermometers and temperature scales, thermal expansion of solids and liquids, temperature and heat, specific heat and latent heat, heat and work in thermodynamic processes, internal energy and the First law of thermodynamics with applications, energy transfer mechanisms	Ch. 18
2.	Kinetic Theory of Gases	Molecular model of an ideal gas, pressure and molecular motion, the meaning of temperature, translational kinetic energy, equipartition of energy, mean free path, distribution of molecular speeds, specific heat of an ideal gas, adiabatic processes for an ideal gas	Ch. 19
3.	Entropy and the Second Law of Thermodynamics	Reversible and irreversible processes, irreversible processes and entropy, the Second Law of thermodynamics, engines and refrigerators, the Carnot cycle, efficiency of real engines, microscopic interpretation of entropy	Ch. 20
4.	Electric Charge and Electric Field	Electric charge, conductors and insulators, Coulomb's law, electric field, electric field calculations (point charge, electric dipole, line of charge, continuous charge distribution), electric field lines, charged particle in an electric field, a dipole in an electric field	Ch. 21-22
5.	Gauss' Law	Charge and electric flux, Gauss' Law, applications of Gauss' Law (cylindrical, planar, spherical symmetries), charged isolated conductor.	Ch. 23
6.	Electric Potential	Electric potential energy, electric potential and potential difference, equipotential surfaces, calculating the potential from the field, examples (point charges, electric dipole, continuous charge distribution), calculating the field from the potential, potential of a charged isolated conductor, the Millikan oil-drop experiment	Ch. 24
7.	Capacitance	Capacitors and dielectrics, capacitance, calculating the capacitance, capacitors in series and parallel, energy stored in an electric field, dielectrics (molecular model of induced charge), Gauss' law in dielectrics	Ch. 25
8.	Current and Resistance	Electric current, current density, resistance and resistivity, Ohm's law, free-electron model of resistivity, materials and conductivity, power in electric circuits	Ch. 26
9.	Direct Current Circuits	Electromotive force, resistors in parallel and in series, Kirchhoff's rules, electrical measuring instruments (the meters), RC circuit	Ch. 27
10.	Magnetic Fields	Magnetic fields and forces, motion of a charged particle in a uniform magnetic field, applications (mass spectrometer, cyclotron, and velocity selector), magnetic force on a current carrying wire, torque on a current loop, magnetic dipole moment, the discovery of electron, the Hall effect	Ch. 28
11.	Sources of the Magnetic Field	Magnetic field due to a current (Biot-Savart Law), magnetic force between two parallel currents, Ampere's law and its applications, solenoids, a current-carrying coil as a magnetic dipole	Ch. 29
12.	Induction and Inductance	Induction experiments, Faraday's law and Lenz' law, induction and energy transfer (motional emf), induced electric fields, inductors and inductance, self-induction, RL circuits, energy stored in a magnetic field, energy density of a magnetic field, mutual induction.	Ch. 30
13.	Circuit Oscillators and Alternating Current	Oscillations in LC circuits, damped oscillations in RLC circuits, electrical-mechanical analogy, AC sources, resistors, inductors, and capacitors in AC circuits, series RLC circuits, power in AC circuits, resonance, transformer	Ch. 31
14.	Maxwell's Equations and Electromagnetic Waves	The displacement current and the general form of Ampere's law, Maxwell's equations (integral form), electromagnetic waves, energy transport and the Poynting vector, radiation pressure, polarization, the electromagnetic spectrum	Ch.32-33
15.	Magnetism of Matter	Magnets, magnetism and electrons, magnetic materials, diamagnetism, paramagnetism, ferromagnetism	Ch. 32

5. Teachers, TAs and Class Schedule

Teacher/TA	Class	Office	Email	Consultation hours
Dr. Tong Shiu Sing	Lectures & Tutorials	SC223	sstong@cuhk.edu.hk	Face-to-face: after class
Ao Kin Pong Tang Yat To Cheung Yiu Hung	Ex Class E01 Ex Class E03 Ex Class E02	SC313 (1T) SC313 (21T) SCG31-32	1155096429@link.cuhk.edu.hk 1155109843@link.cuhk.edu.hk 1155127196@link.cuhk.edu.hk	Mon 11:30 – 13:15 Mon 13:30 – 15:15 Fri 10:30 – 12:15

	Lectures & Tutorials		Exercise Classes		
			E01	E02	E03
Time	Tue 10:30 - 12:15	Thu 16:30 - 18:15	Mon 10:30 - 11:15	Mon 17:30 - 18:15	Tue 18:30 - 19:15
Venue	Lee Shau Kee Building LT1	T. Y. Wong Hall LT	Mong Man Wai Bldg. 715	Mong Man Wai Bldg. 715	Hui Yeung Shing Bldg. 501

Students can choose to attend any **ONE** of three repeated exercise classes. The *first* Exercise Class will be held on **September 13 (Tue class) /19 (Mon class), 2022**.

6. Assessment Scheme

Your performance will be assessed according to the Assessment Scheme shown in the table below. The midterm examination will be held on **October 27, 2022** during the lecture hours. The final examination will be arranged by the University. The homework assignments will be graded by the TAs and the graded assignments will be returned to you two weeks after submission. If you have enquiries concerning the grading, please feel free to contact the TA (name written in the assignment) who is responsible for grading the assignment.

	Homework	Mid-term exam	Final exam
Weight	15 %	35 %	50 %
Date & Time	Weekly unless otherwise stated (note due time on assignments)	October 27, 2022 (lecture hours)	Arranged centrally
Venue	---	T. Y. Wong Hall LT	Arranged centrally

Important notice: You will fail the course if you are **unable to get at least 20% of the marks of all written examinations** (midterm and final). In addition to this requirement, your total marks (calculated according to above table) still have to be above the passing mark in order to pass the course. The passing mark and the mark of each grade will be decided by the Panel of Examiners of the Physics Department according to the Grade Descriptors listed in Section 10 of this course outline.

7. Learning Activities

The table shows the expected time that you would spend on each learning activity, averaged over the semester.

Lectures and Tutorial (hr / week)		Flipped Classroom (hr / week)		Exercise Class and Homework (hr / week)	
in class	outside class	in class	outside class	in class	outside class
3	3	0	0.5	0.75	3.5

Lecture and Tutorial

The essential concepts of the course will be taught in the lectures. Students are required to study the course materials after class and encouraged to raise questions and interact with the teachers and TAs. The tutorials will also involve teaching supplementary materials and doing class exercises.

Homework

Homework assignments will be uploaded in the Blackboard course website. Students should to **submit their homework to Blackboard by the due time. NO late submission will be accepted.** The graded homework will be available for review on Blackboard two weeks after the due time. The due time and the TA responsible for a homework will be written at the top of the homework. If you have enquiries concerning the grading, please contact the TA responsible directly. The problems in homework are divided into three categories:

Basic problems (30%): Problems that provide you with training on the basic skills and knowledge you learned in lectures.

Structural problems (70%): Problems that are more structural, giving you necessary practice and enhance your understanding.

Optional challenging problems (0%): Problems that are optional, more context-based and challenging, may involve new concepts for self-study. These problems will be graded but will **NOT** be counted towards your final grade.

Plagiarism of homework is prohibited with zero tolerance and subject to disciplinary actions by the University. See the University policy of academic honesty in Section 8 below.

eLearning Micro-modules

Most topics on mathematical skills will be covered in lectures. More difficult topics (will not be examined) are included in the eLearning micro-modules: multiple integrals, line integral, gradient, flux and surface integral, etc. They can be accessed at the following website:

http://www.phy.cuhk.edu.hk/elearning/phys2041/

The eLearning Micro-modules on mathematical skills developed by the Physics Department are provided on the following page, with direct links to facilitate searching for a particular topic.

http://www.phy.cuhk.edu.hk/elearning/maths.html

The Micro-modules on this page include pre-university level mathematical skills for filling any initial gaps, and the extensions that go beyond the requirements of this course.

Exercise Class

Each exercise class is led by a TA. Guided by the TAs, you will be asked to work on one additional problem. The problem will **NOT** be given to you beforehand and the solution will **NOT** be posted on the web, so you are required to go through the entire thinking process of approaching and solving a problem during class. This is a valuable opportunity for you to train your problem solving skills and learn through interacting with others.

Consultation Hours and Interactions Outside Class

Each TA has his/her own consultation hours. Students are strongly encouraged to use these sessions to interact with the TAs and ask questions related to their learning. Students are also strongly encouraged to **interact with the teacher after class, through emails or telephone, or request an appointment via Zoom or in person.**

8. University Policy on Academic Honesty

Plagiarism is prohibited with zero tolerance and subject to disciplinary actions by the University. Attention is drawn to University policy and regulations on honesty in academic work, and to the disciplinary guidelines and procedures applicable to breaches of such policy and regulations. Every student should read and understand the University policy on academic honesty available at:

http://www.cuhk.edu.hk/policy/academichonesty/

In the first lecture, you are required to sign a **Declaration of Academic Honesty Statement**. Please sign and return it to the teacher after you have read the disciplinary guidelines and procedures on academic honesty stipulated in the above website.

9. Feedback for Evaluation

Your feedback is very useful for improving the course. There are several channels for you to provide comments and feedback. You can

- send an email to us, give us a phone call, or come to discuss with us in person; especially for issues that require immediate action;
- post a message on the Facebook group or web forum of the course website;
- express your views in course evaluation; and/or (e.g. ask a student representative to help you convey the messages) in the staff-student consultation meeting held every year.

10. Grade Descriptors

Your grade in this course will be assessed based on the following grade descriptors.

Grade	Descriptions
A	Demonstrate thorough mastery of principles and subject matter in the course required for attaining all the course learning outcomes. Demonstrate the ability to apply the principles or subject matter to familiar and unfamiliar situations, in a manner that would surpass the normal expectation at this level and standards that may be required at higher levels of study or research. Has the ability to express the knowledge or synthesis of ideas in a clear and cogent manner.
A-	Demonstrate substantial command of principles and subject matter in the course required for attaining almost all the course learning outcomes. Demonstrate the ability to state and apply the principles or subject matter to familiar and some unfamiliar situations, in a manner that is logical and comprehensive. Has the ability to express the knowledge or application with clarity and accuracy.
B	Demonstrate general and sufficient command of principles and subject matter in the course required for attaining most of the course learning outcomes. Demonstrate the ability to state and apply the principles or subject matter accurately to most (but not necessarily all) familiar and standard situations, in a manner that is logical and persuasive. Has the ability to express the knowledge or application in a satisfactory and unambiguous way.

C	Demonstrate general command of principles and subject matter in the course required for attaining some of the course learning outcomes. Demonstrate the ability to state and apply the principles or subject matter to most (but not necessarily all) familiar and standard situations, but with occasional errors and/or in a manner that is fragmented. Has the ability to express the separate pieces of knowledge in an unambiguous way.
D	Demonstrate partial command of principles and subject matter in the course required for attaining some of the course learning outcomes. Demonstrate the ability to state and apply the principles or subject matter to some simple situations only. Has the ability to state the knowledge or application in simple terms.
F	Demonstrate little or no evidence of command of principles and subject matter in the course required for attaining the course learning outcomes, OR failure to meet specified assessment requirements.