



Electricity and magnetism I

Dr. Li Xinwei

Department of Physics

A crucial pillar in physics

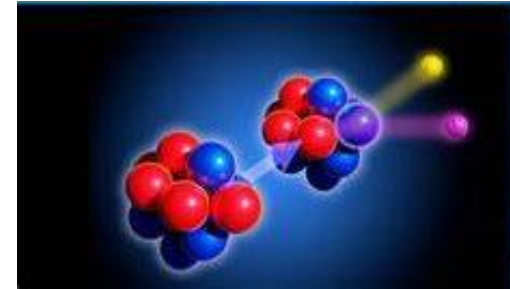
Fundamental forces in nature

Gravitational



Why apples fall

Weak



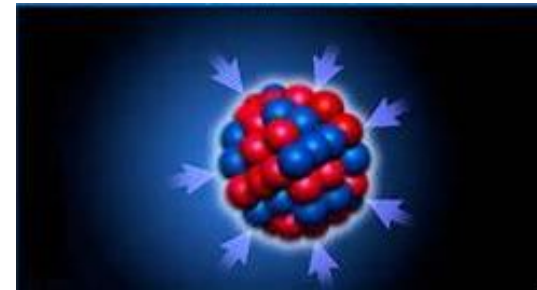
Radioactive decay

Electromagnetic



Ubiquitous in nature

Strong



Holds proton and neutron together

Mechanics

How a system would behave when subjected to a given force?

Classical mechanics: normal objects in daily life

- Newtonian mechanics
- **Electrodynamics**
 - Most well established, least controversial
 - Highly relevant and can be extended to other three types of mechanics

Quantum mechanics: small objects

Special relativity: objects moving at fast speeds

Quantum field theory: small objects moving at fast speeds

Topics

1. Vector calculus

2. Electrostatics

- Charge, electric force, electric field
- Electric potential
- Electric fields in matter

3. Magnetostatics

- Current, magnetic force, magnetic field
- Magnetic vector potential
- Magnetic fields in matter

4. Electrodynamics

- Electromotive force
- Electromagnetic induction
- Maxwell's equations

5. Electromagnetic waves

- EM waves in vacuum
- EM waves in matter
- Guided EM waves
- Radiation

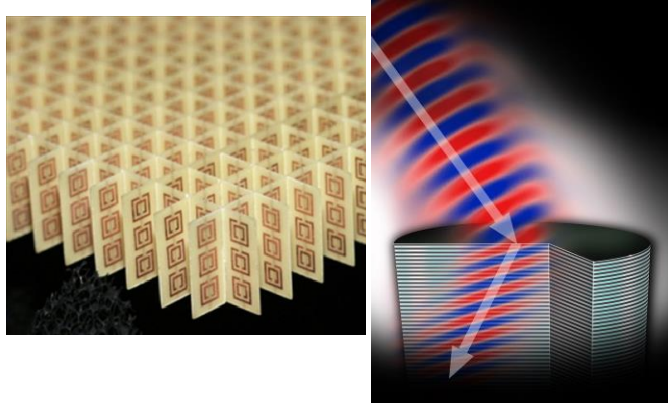
6. Relativity

- Theory of special relativity
- Relativistic mechanics
- Relativistic electrodynamics

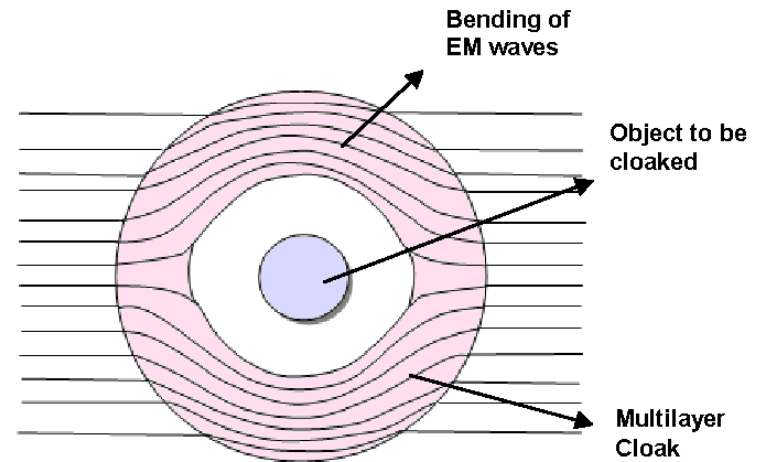
Research frontier

Metamaterials and plasmonics

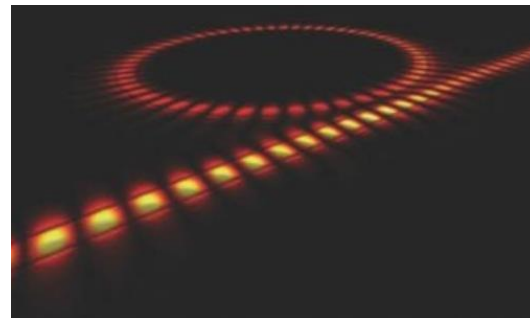
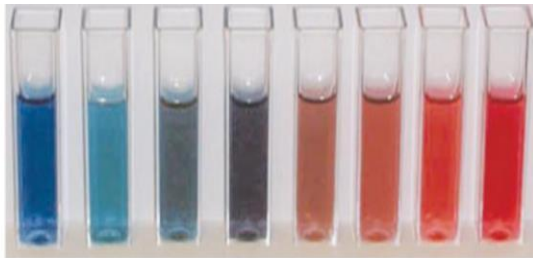
Negative refractive index



Invisibility cloak

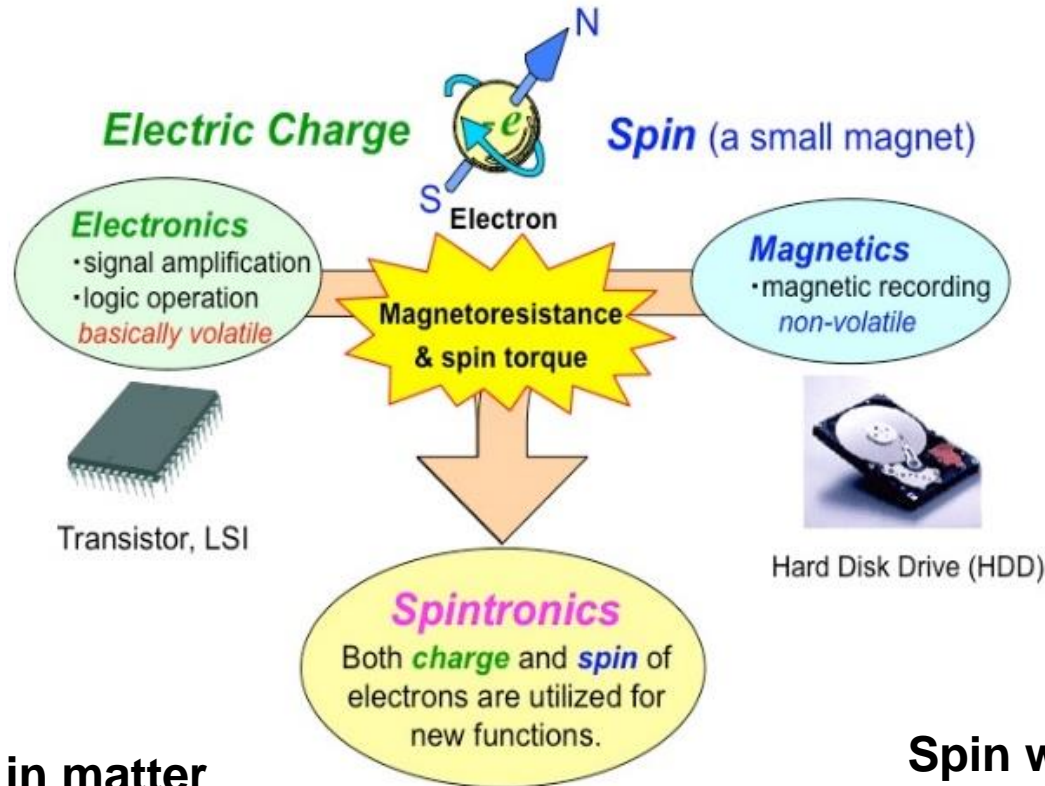


Plasmonics



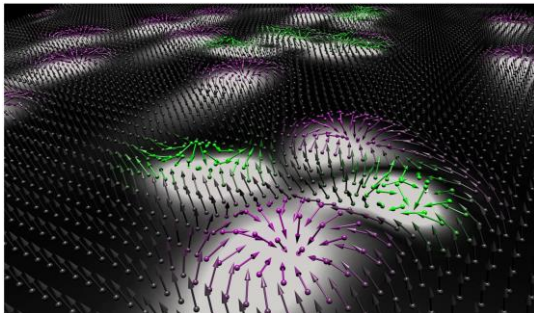
Choudhury 2013
Wienhoven 2021
Bioparticles.com
Advanced science news

Spintronics

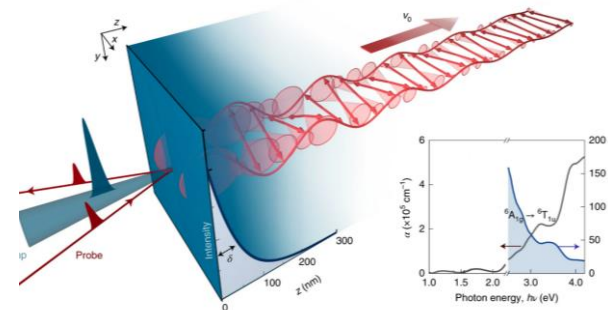


Kushwaha 2013
Ritzmann 2018
Hortensius 2021

Spin texture in matter

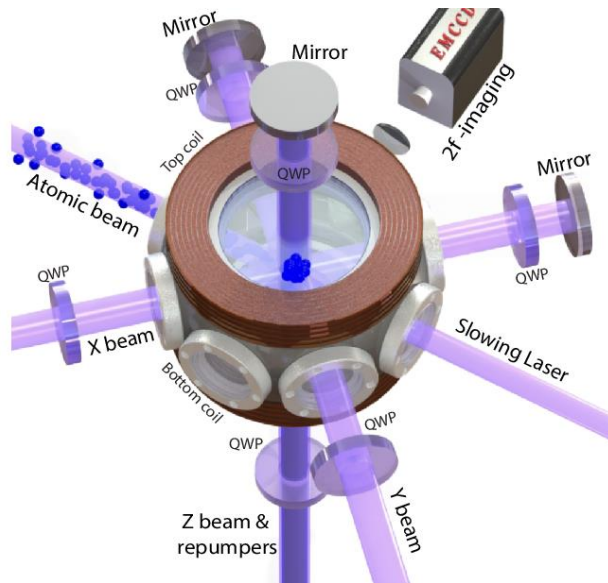


Spin wave



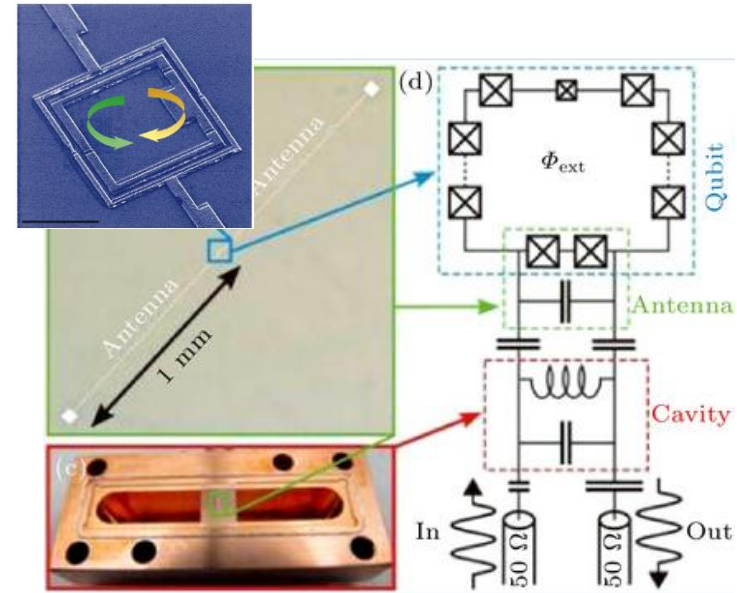
Quantum computing

Cold atoms



Magnetic optical trap
(at NUS CQT)

Superconducting qubits



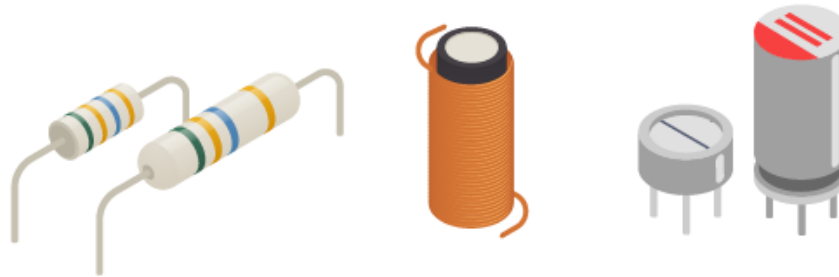
Fluxonium

Su 2022

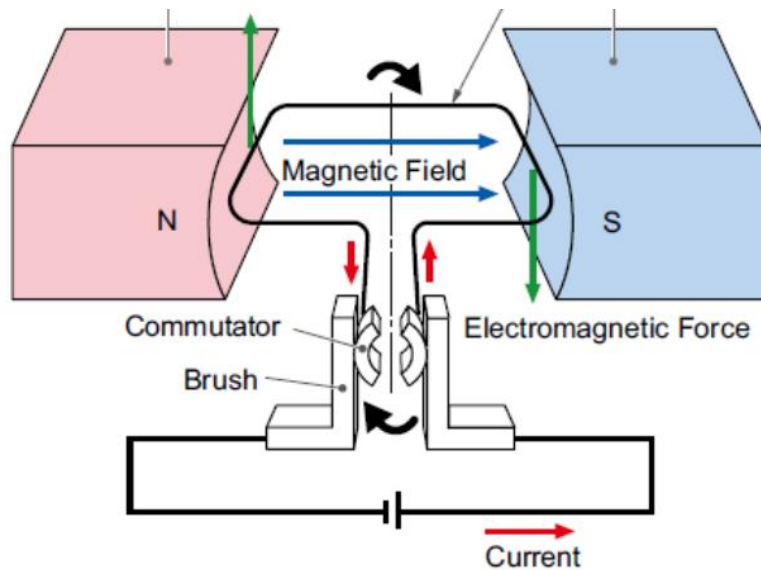
Applications

Daily applications

Resistor-Inductor-Capacitor



Electric motors



Magnetic compass



Faraday cage

Electrical isolation enclosure that protects human and sensitive equipment from lightning strikes

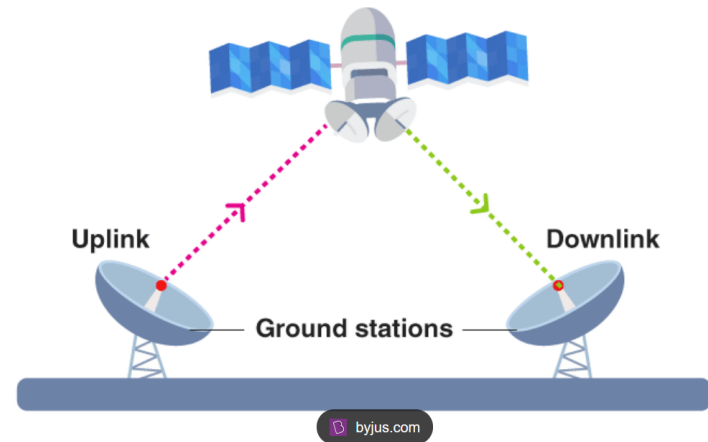


Telecommunication

Radio



Satellite



Optical fiber

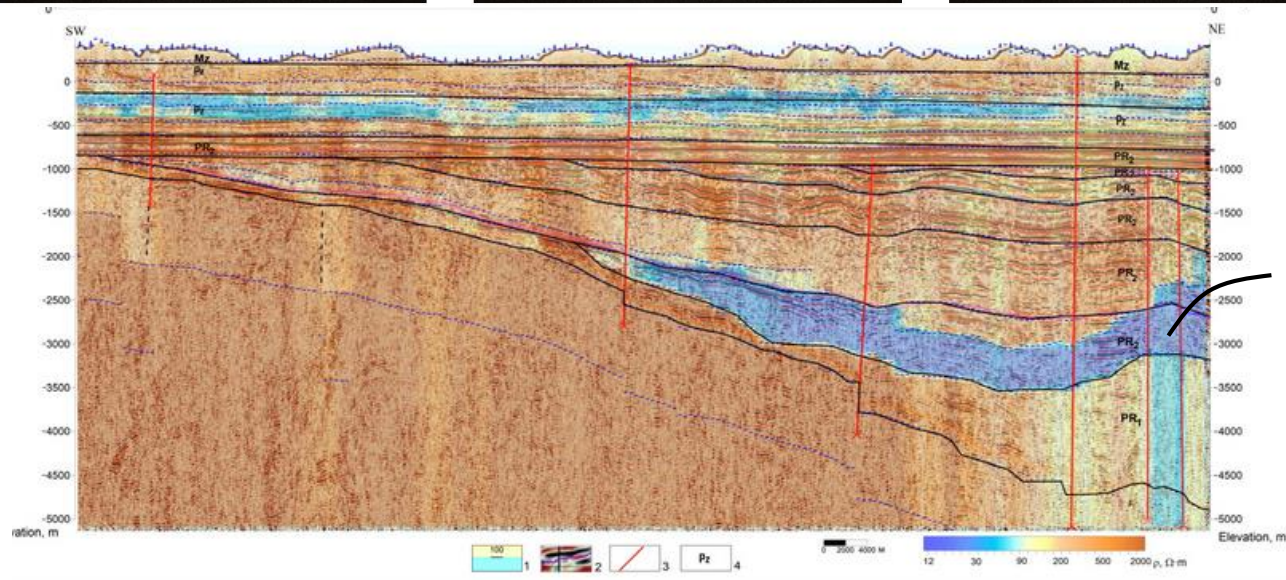
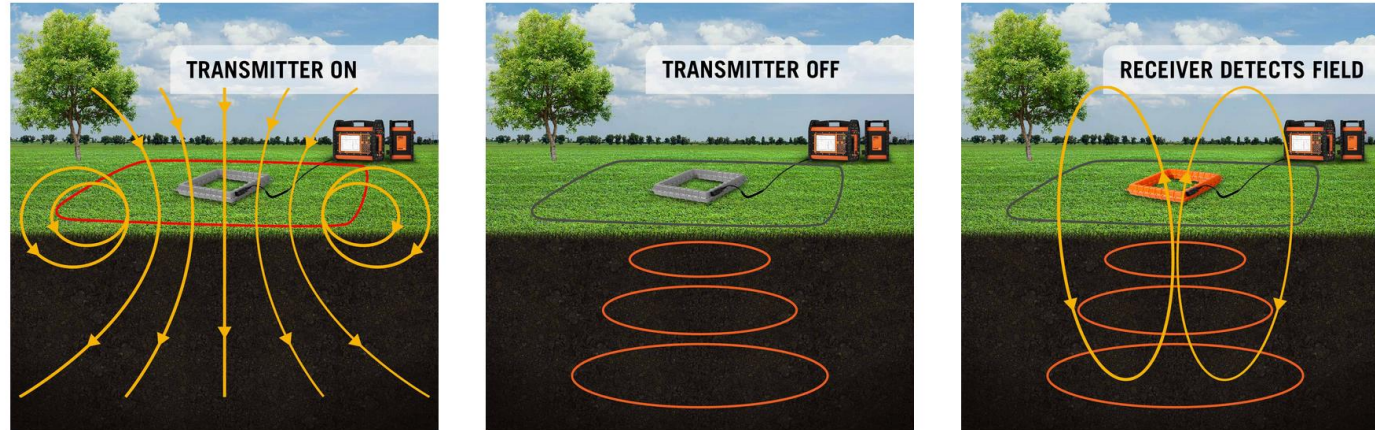


Radar



Geophysical techniques

Transient electromagnetic survey



Underground
water/minerals/oil

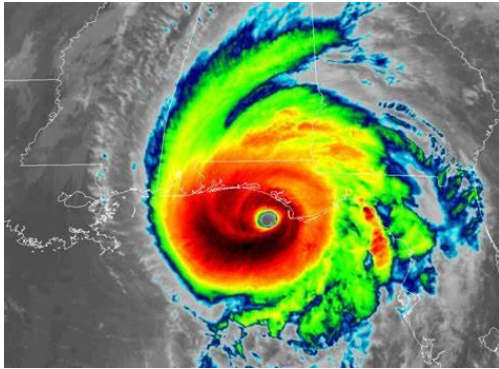
Cross-sectional mapping of seismic resistivity

Buddo 2022

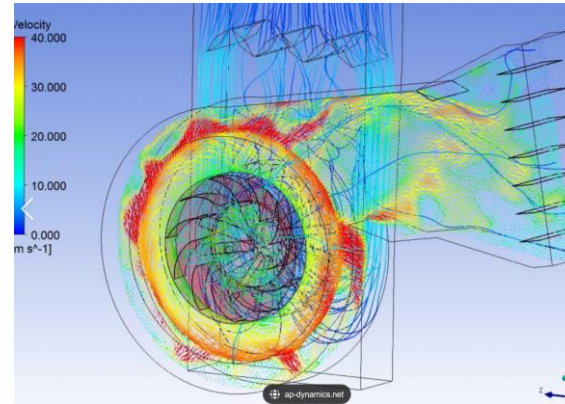
Mathematical tools

Vector calculus, linear algebra, ordinary differential equations, partial differential equations

Weather forecasting



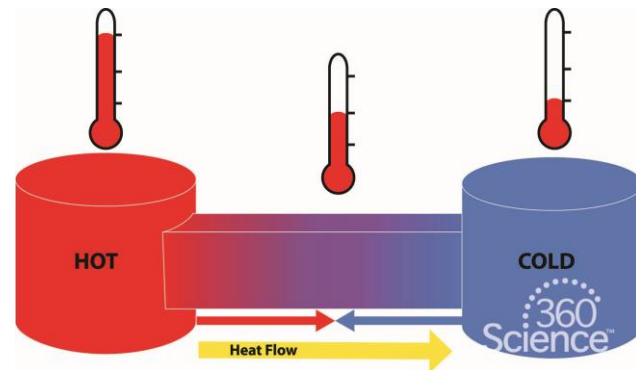
Fluid dynamics



Financial market



Thermal problems



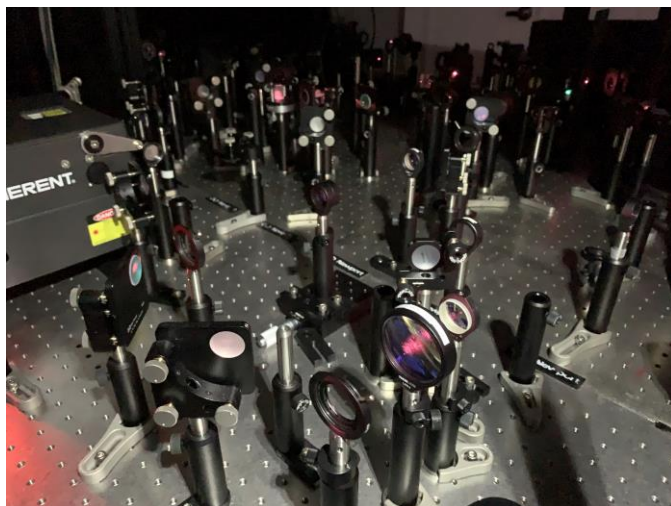
Course facts

Term:	2024 Sem1	Lecture days:	Mon. & Thurs.
Instructor:	Li Xinwei	Lecture time:	10 am – Noon
Email:	xinweili@nus.edu.sg	Venue:	M: LT29, T: LT27
Office hour:	Wed. 11 am - noon	TA:	Yang Hengxing (hengxing@u.nus.edu)

Instructor: Li Xinwei (office: S12-02-08)

Lab of light-matter interaction

<https://www.lixinweigroup.com/>



Asst/Prof @ NUS Physics

July 2023 -

Postdoc @ Caltech Physics

2019 - 2023

Ph.D. @ Rice ECE

2014 - 2019

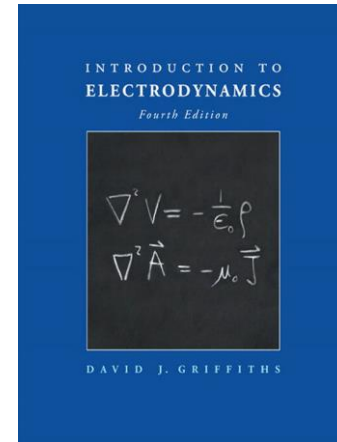
B.Sc. @ Fudan Physics

2010 - 2014

Textbooks

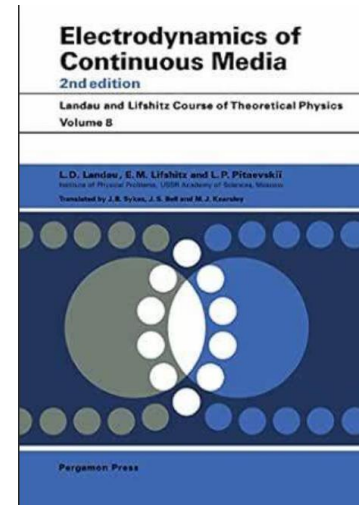
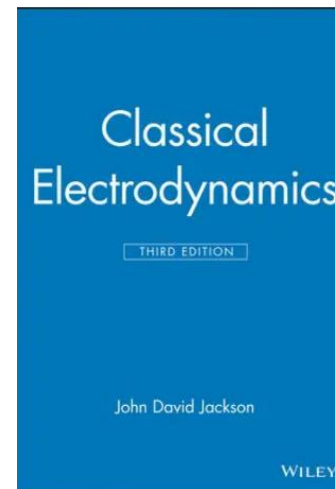
Main:

- David J. Griffiths. *Introduction to Electrodynamics*. 4th ed., Pearson Education, Inc., 2013. ISBN: 978-0-321-85656-2



Supplementary:

- John David Jackson. *Classical Electrodynamics*. New York, John Wiley & Sons, Inc., 1998. ISBN: 978-0-471-30932-1
- Landau and Lifshitz. *Electrodynamics of continuous media*, Oxford: Pergamon Press Ltd., 1961.



Assessment components

Component	Weight	Description
Quizzes/attendance	15%	3 – 5 times, randomly called upon throughout semester
Homework	25%	4 – 6 sets
Final exam	60%	Closed book test (with one A4 help sheet), in the exam week

Assessment components

- **Quizzes/attendance (15%)**
 - 3 – 5 times, randomly called throughout semester
 - In the form of unannounced quizzes, to be turned in at the end of class
 - Half score for signed name (attendance), the other half graded
- **Homework (25%)**
 - 4 – 6 sets of assignment questions
 - Submit to Canvas in .pdf format (typed or scanned handwritten copy)
 - Late submissions without excuse penalized proportional to lateness
 - May include some open-ended questions or those requiring coding

Assessment components

- **Final exam (60%)**
 - Covers all course contents throughout semester
 - Closed book, with an A4 help sheet (both sides)
 - Nonprogrammable calculator

Academic integrity

NUS code of student conduct

“The University takes a strict view of cheating in any form, deceptive fabrication, plagiarism and violation of intellectual property and copyright laws. Any student who is found to have engaged in such misconduct will be subject to disciplinary action by the University. Such misconduct will include, but is not limited to, the misuse of content or language generated by artificial intelligence (AI) computer programs.”