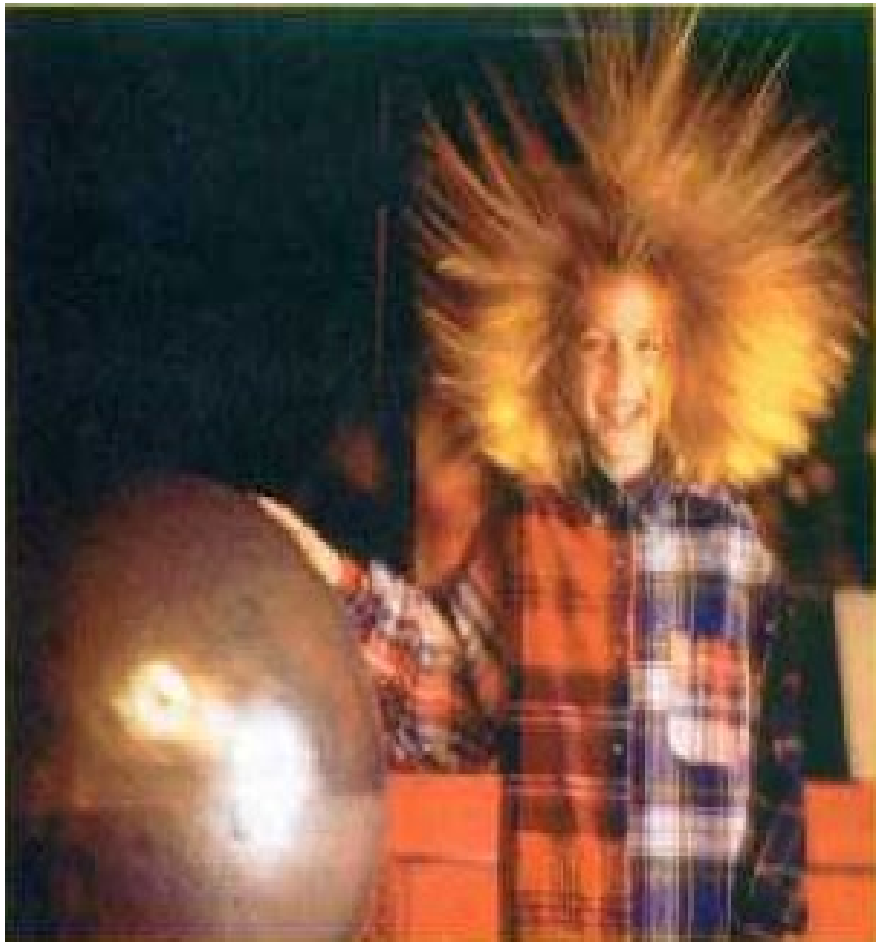
Field and Wave Electromagnetics

电磁场与电磁波

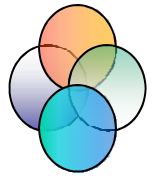
Yaojun Qiao

(乔耀军)

2018.03.05



Foreword



- What is EMF?
- Why shall we study EMF?
- How does EMF evolve?
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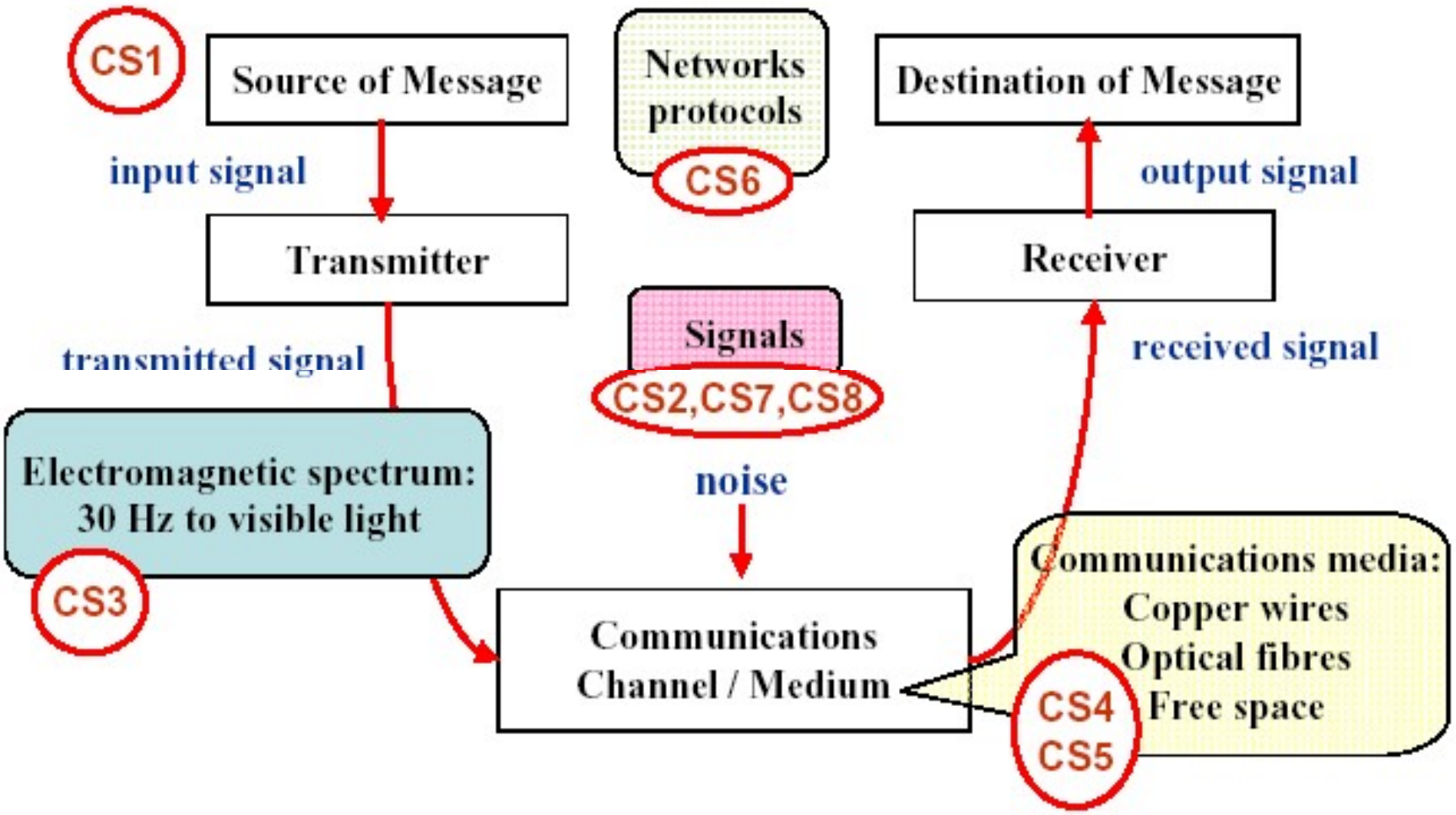
- How to lean this course?

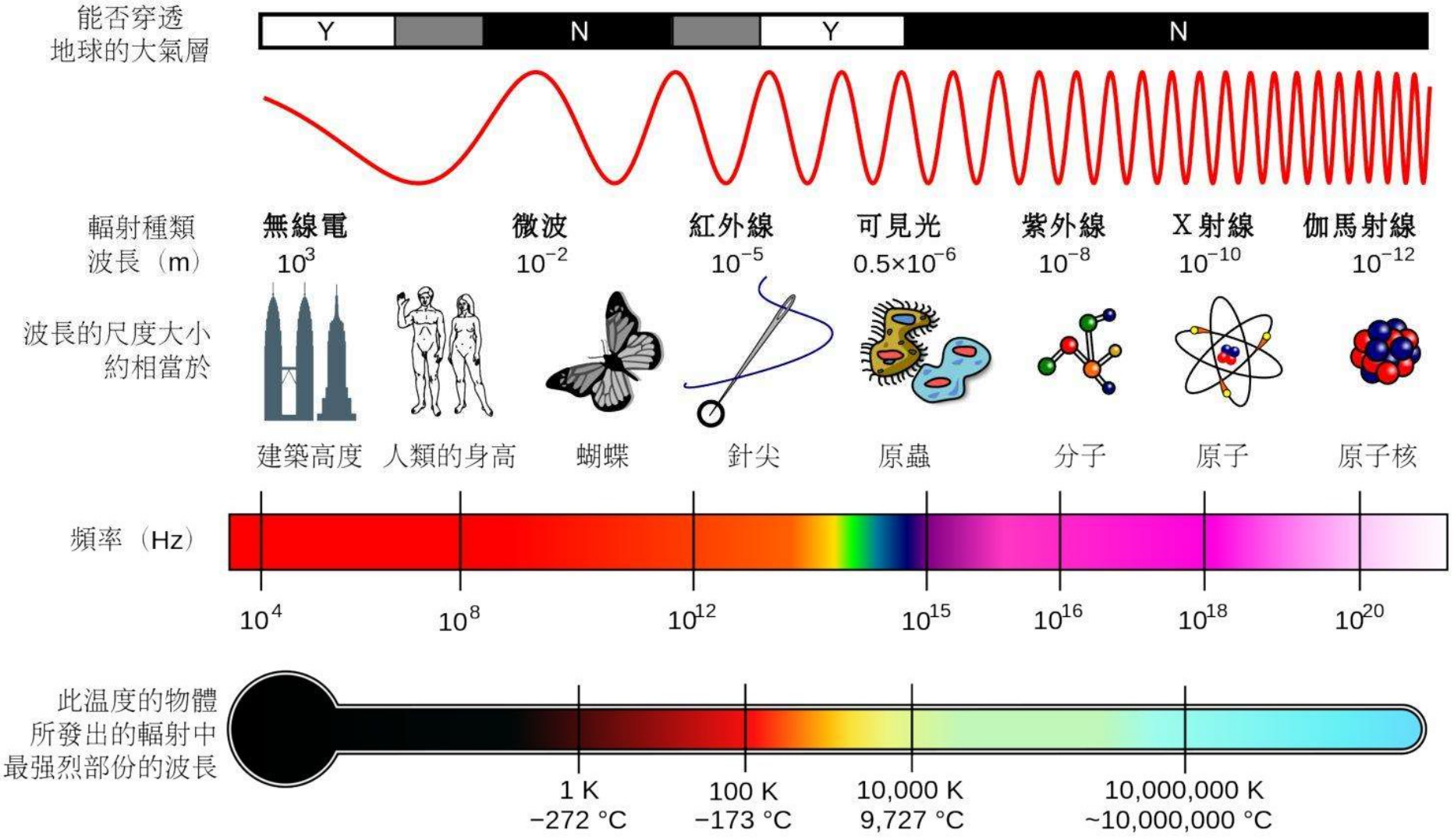
EMF: ElectroMagnetics Field

EMW: ElectroMagnetics Wave

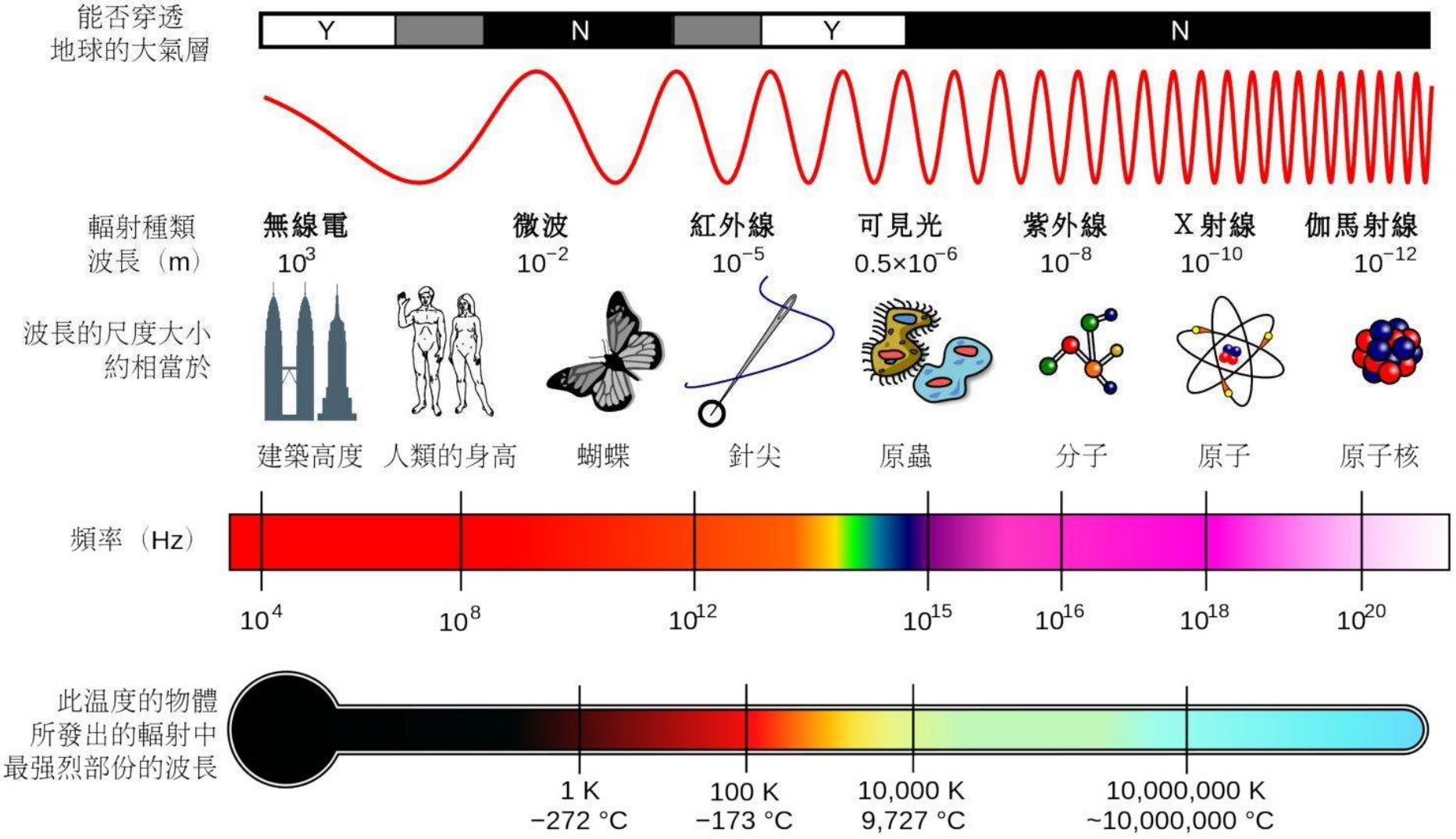
Overview of Communication system



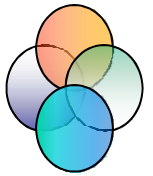
ElectroMagnetics Wave



ElectroMagnetics Wave



Foreword



- What is EMF?
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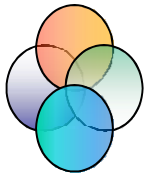
Why shall we study it?

- In fact, we are **living in a wor**
  magnetic waves

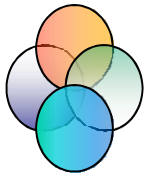
Field and Wave Electromagnetics

Why shall we study it?



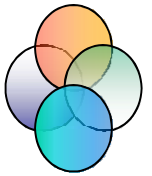
- In fact, we are **living in a world** full of electronic & magnetic waves
  - Mobile, satellite, broadcast, circuits >10Mb/s, TV antenna
  - Lightning arrester(避雷器), **Electromagnetic compatibility** (EMC), Electronic Warfare, etc.
- It's one of the **most important fundamental courses** of the ***Electrical engineering & communication technologies***
  - A significant **pillar** to support the knowledge temple of a qualified student in Communications Science or Electronic Engineering;
  - Serving as a preparation for both wire and wireless advanced courses.

Related Wireless Commu. Courses



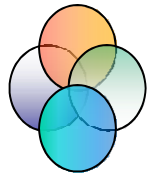
- Mobile Radio Communications移动通信技术
- Technologies of Remote Control & Remote Measurement遥控遥测技术
- Fundamentals of Microwave Technology微波技术基础
- Microwave Communications微波通信
- Microwave Networks and Circuits微波网络与电路
- Microwave Measurements微波测量
- Satellite Communications卫星通信
- Antenna and Propagation天线和传播
- Antenna Measurements天线测量
- Digital Microwave数字微波
- Radio Wave Propagation无线电波传输

Related Wired Commu. Courses



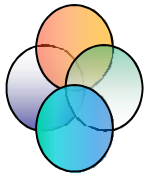
- Cable Television Technology有线电视技术
- Optical Fiber Communications光纤通信
- Optical Cable Engineering光缆工程
- Theory of Transmission Lines传输线理论
- Optical Fiber Sensors光纤传感器
- Guided Wave Theory导波理论
- Optical Components and Opto-Electronic Devices光器件和光电子器件
- Theory of Optical Waveguide光波导理论
- Foundation of Photoelectric Transform光电变换基础
- Integrated Optics集成光学
- Nonlinear Optics非线性光学
- Digital & Data Communication Principal数字与数据通信原理
- Optoelectronic Components in Communications Systems通信系统中的光电子器件
- Optical Fiber Measurements光纤测量
- Optical Access Networks光接入网
- High-speed Components for Optical Communications光通信中高速器件
- Photonic Switching光交换技术
- Broadband Communication Networks宽带通信网络

Aims of This Course



- The aim of this course is to introduce the basic laws of electromagnetism and thus provide a **fundamental comprehension of electromagnetic fields and waves.**
- It is based around the development and use of Maxwell's equations in integral form.

Foreword



- What is EMF?
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- **How does EMF evolve?**
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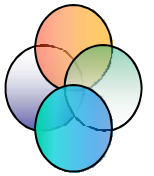
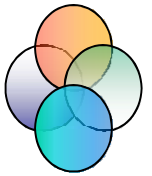
EMF: ElectroMagnetics Field

A History of Electromagnetics



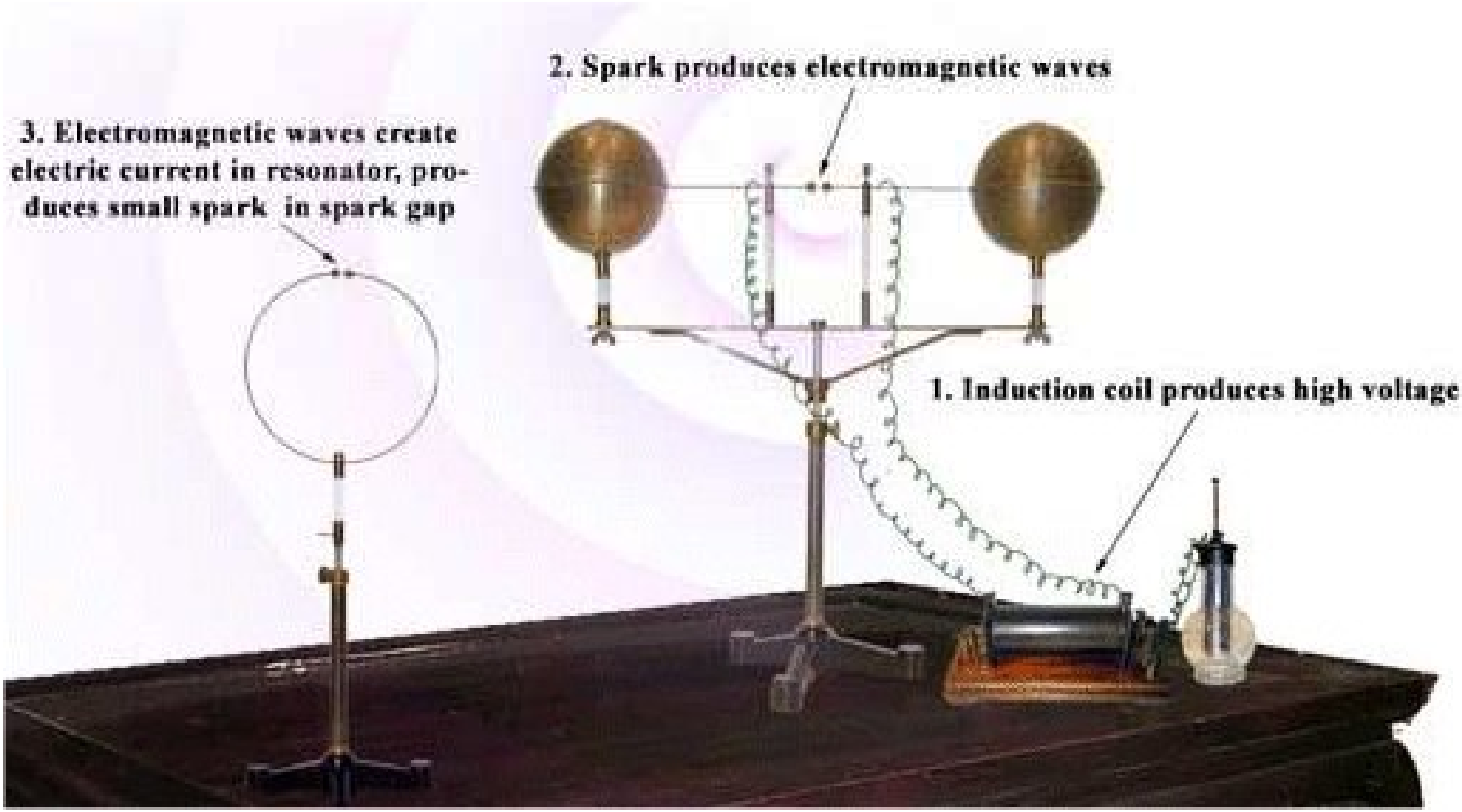
- 600 B.C., Greece
  - Rubbed amber（摩擦后的琥珀） may attract tiny objects
- 300 B.C., China
  - Lodestone（磁石）
- Right after A.D., China
  - The First Compass (指南针) in the world
  - Note that the name of China vanished from this list from then on.
- A.D. 1785 France
  - Coulomb库仑(1736~1806) and Coulomb's Law
- A.D. 1820 Danmark
  - Oersted奥斯特(1777~1851): Magnetic field around the current

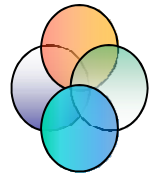
A History of Electromagnetics



- A.D. 1820, France
  - Ampere安培 (1775~1836) Ampere's Law: force between currents
- A.D. 1831, England
  - Faraday法拉第 (1791-1867)
  - Law of Magnetic Induction --- E field can be generated by changing M field.(法拉第电磁感应定律)
- A.D. 1873, England
  - Maxwell麦克斯韦 (1831-1879)
  - **Displacement current** (位移电流) time varying E filed generates M field, give Maxwell Equations
- A.D. 1887, Germany
  - Hertz赫兹 (1857~1894) Validate Maxwell Equations, and the existence of EM wave

Hertz Experiment Setup(1887)

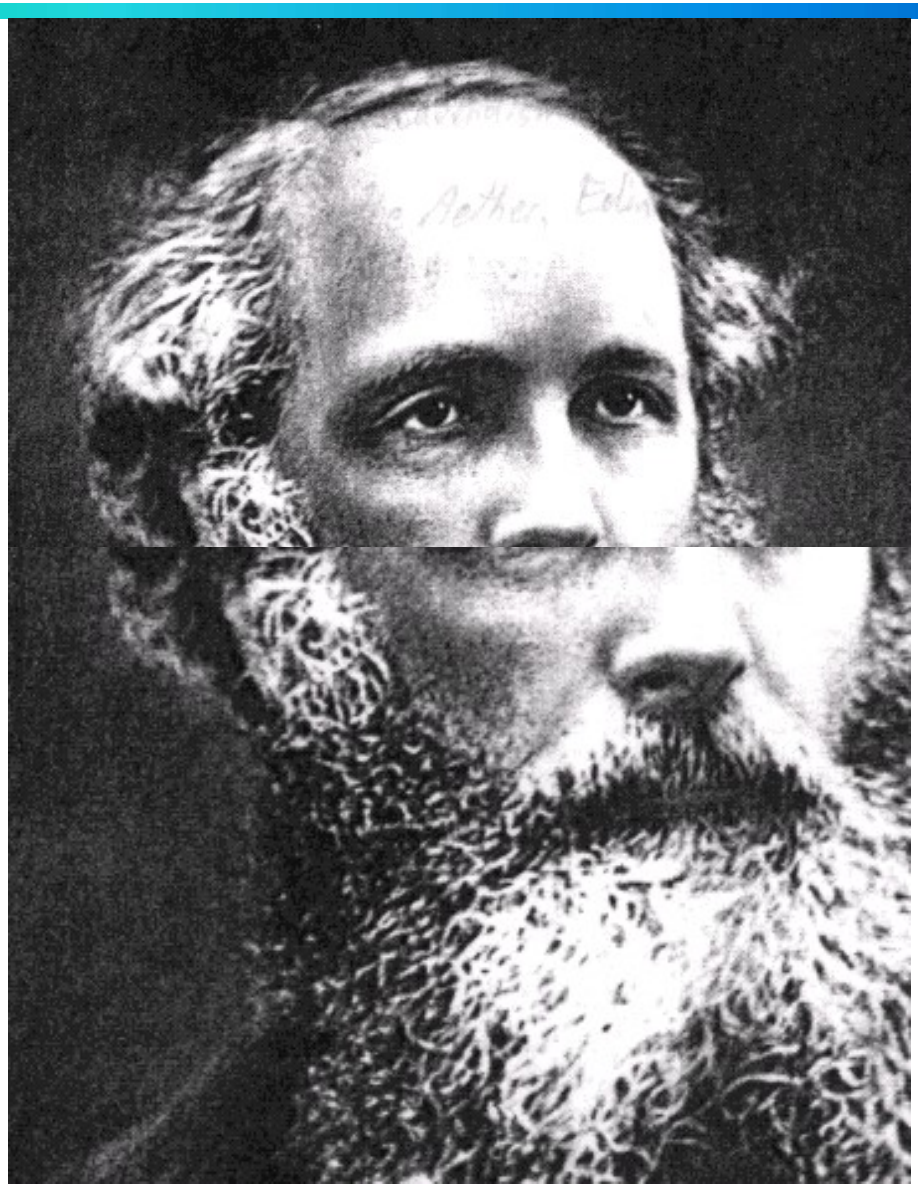




In modern history, Popov in Russia and Marconi in Italy

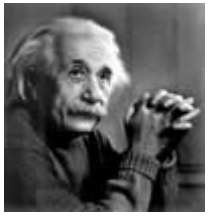
- EM waves were used to carry the information
- Wireless at first, and wired later on

Something about Maxwell



Something about Maxwell

- He is Great!
- Great expert in Electro-magnetics! Corrector of "*the kinetic theory of molecule* 分子运动论的修正者".
- Theory of EMF is like a **relay race** and Maxwell is one of the team members to relieve the last run.
  - This race has lasted for about half century, beginning with the magnetic induction of the current by Oersted and Ampere, succeeded by Faraday, and then fulfilled by Maxwell.
- He is a genius!
  - A genius with a short life of 48 years;
  - In the year he came into the world, Faraday discovered magnetic induction;
  - **In the year he left us, another genius came.**

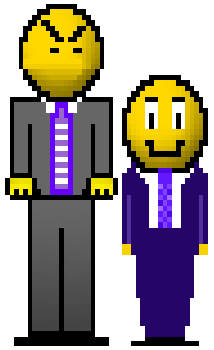


——Einstein

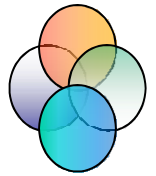
Something about Maxwell——2

- He expressed outstanding faculty from childhood.
  - Publishing a paper on mathematics at **15**;
    on *Transaction of Edinburgh Royal Society*;
    about the geometric drawing of conic二次曲线的几何作图;

- At 24, He published "On Faraday's **Lines of Force**"
  - Describing the Faraday's Lines of Force in mathematical language for the 1st time and thus establishing a maths bridge between the electronics and the magnetics.
  - Faraday said to him, "I do not think my theory is definitely the truth, but you are the one who understand it in deed. You should not be satisfied with expressing my theory mathematically. It's your mission to exceed it."



Something about Maxwell——3



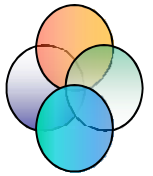
- At 31, he published "On Physical Lines of Force"
  - Bringing forward the concepts of **displacement current** and EMF, giving a systematic maths expression o EMF theory, and forecasting the existence of EM waves.
  - 他认为变化的电场必激发磁场，变化的磁场又激发电场，这种变化着的电场和磁场共同构成统一的电磁场。电磁场以横波的形式在空间传播，形成所谓电磁波。
- At 34, he published "Dynamics of EMF" 《电磁场动力学》
  - Calculating the propagating velocity of EM waves and claiming the light is a kind of EM wave.

Something about Maxwell——4

- At 42, he published the monumental works "A Treatise on Electricity and Magnetism"《电磁通论》.
  - This books **can compete with** any invaluable intelligence crystal of human kind ever in the world, such as "Philosophiae Naturalis Principia Mathematica"(自然哲学的数学原理) by Newton and "Origin of the Species" (物种起源) by Darwin.
  - Einstein called Maxwell's equs. "the most important invention since Newton's time".
- As we get aware of the ubiquity of EM waves in the world, we cannot help calling to mind this great mathematical physicist.

喝水不忘挖井人

Foreword



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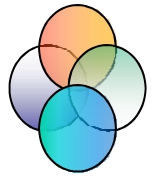
EMF: ElectroMagnetics Field

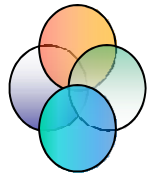
Contents



Stars * represent contents of self-study; Green contents are nodi.

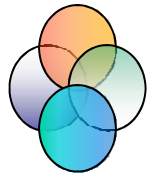
- **Chpt.1** Vector Analysis
  - 3 degrees and 3 laws
    - Gradient, Divergence, Curl
    - Gauss's Law, Stokes's Law, Helmholtz Theorem
- **Chpt.2** Electrostatics
  - Fundamental Equs., Electric Potential, Electric Dipole, Dielectric Materials *
  - **Boundary Conditions, Capacitors and capacitance,** Force and Energy in E Field *
- **Chpt.3** Magnetostatics
  - Fundamental Equs., **Boundary conditions, Magnetic vector potential,** Magnetic Dipole *
  - **Inductance**, Force and Energy in M Field *

Contents——2



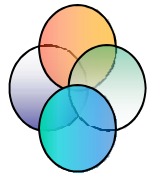
- **Chpt.4** Steady Electric Currents
  - Fundamental Equs.
  - **Boundary conditions**
  - Analogy between **static** E and **steady current** E
- **Chpt.5** **Mathematical Solutions of Steady Field**
  - Poisson Equation, Laplace Equation
  - Method of variable separation
    - Cartesian（笛卡尔） coordinates, Cylindrical coordinates, Spherical coordinates*
  - Method of mirror image
    - Plane imaging, Cylinder imaging*, Sphere imaging, Dielectric imaging

Contents——3



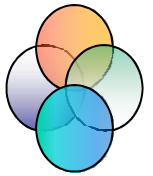
- **Chpt.6** Time-varying EMFs
  - **Maxwell's Equations & boundary conditions**
  - Poynting's Law & Poynting Vector
- **Chpt.7** Plane Waves
  - General wave equations, Parameters of plane wave propagation
  - **Polarization of plane waves**
  - Plane wave in a good conductor (the loss, penetration depth, Surface impedance
  - Plane wave in a dielectric *

Contents——4



- **Chpt.8** Reflection and refraction of plane waves
  - Normal incidence of uniform plane waves
  - Oblique incidence on a plane boundary (Reflection Law, Refraction Law, Critical Angle, Brewster Angle, Fresnel's Formula
- **Chpt.9** Waveguides
  - Wave equations in Cartesian coordinates
  - Single mode operation and TE_{10} Mode
- **Chpt.10** Antennas
  - A short dipole antenna
  - Field in local and remote area
  - Direction indication

Foreword



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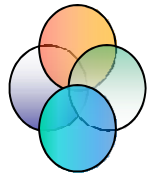
About the Exam

- Homework, must on time 20%
- Midterm Exam, chapter 1~5 20%
- Final Exam, chapter 6~9 60%

- It is a very basic, important, and useful course, and also very difficult
- Traditionally, large percent students fail to pass this course.
- I hope everyone in this class work hard and pass the final.



Any suggestions and comments are welcome!

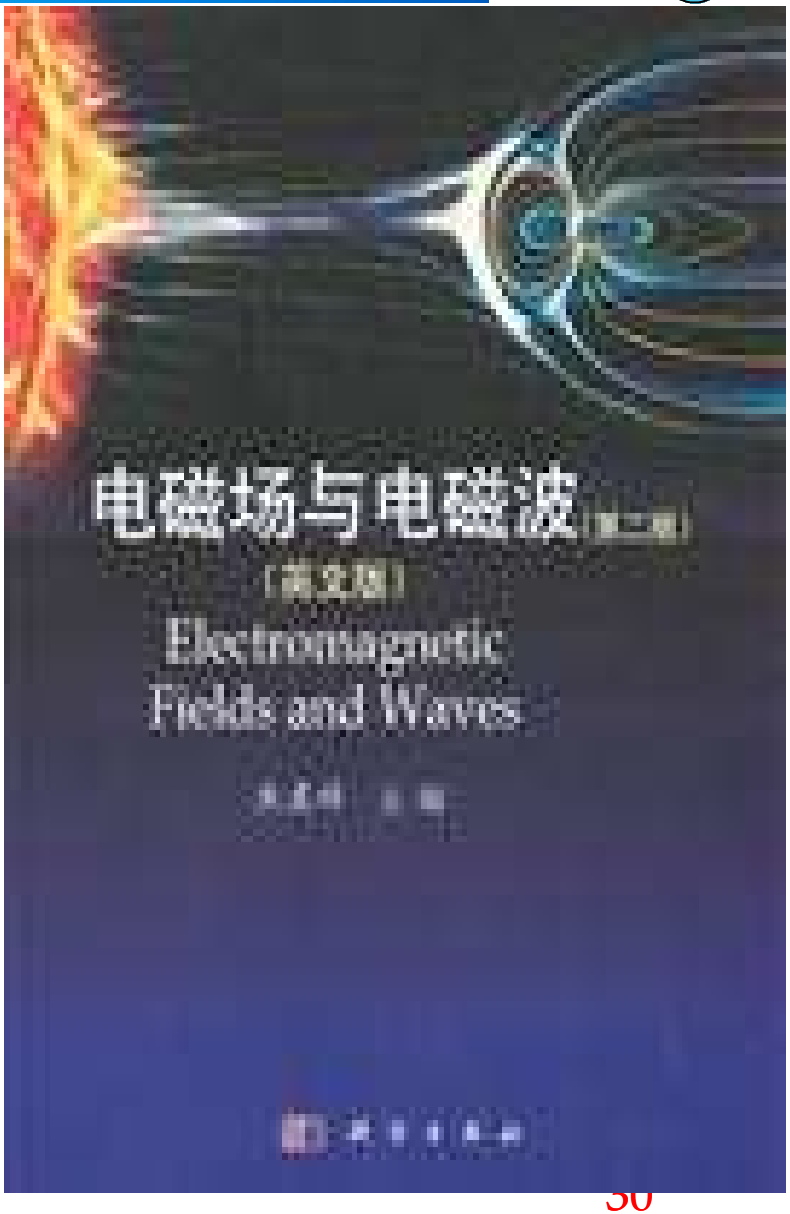
And

Everyone is encouraged by bonus to point out the mistake in the lecture notes, by any way you like.

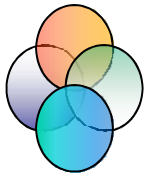
Textbook

- Authors: Jiao Qixiang（焦其祥）
- Title: Electromagnetic Fields and Waves (Second Edition)

- 即：《电磁场与电磁波》(第2版), 科学出版社，2012年7月



References



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- Field and Wave Electromagnetics, David K. Cheng, 2nd edition, 清华大学出版社，2007
- 《电磁场与电磁波》，焦其祥、顾畹仪等编著
  - 科学出版社。
- 《电磁场与电磁波》，谢处方、饶克谨著
    - 高教出版社

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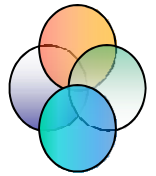

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英文参考教材：

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2. Field and Wave Electromagnetics, David K. Cheng, 2nd edition, 清华大学出版社，2007

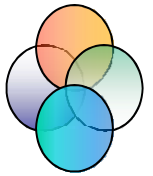

国院2016级123班
EMF答疑
该二维码7天内(3月8日前)有效，重新进入将更新

Where can you reach me?

- **Office: Room 505, Mingguang Building , Main Campus, BUPT (本部明光楼505)**
- **Email: qiao@bupt.edu.cn**

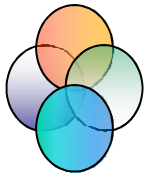
- **_____Yaojun. Qiao _____**

Feel free to contact me !



- **If you, by chance, have some questions, suggestions, or comments;**
- **By any way you like, such as face-to-face discussion, Phone, E-mail etc……**
- **I will answer you ASAP.**

Some Advice



- This course is really something of a challenge.

① Vector analysis is very important, it is the basic language of EMF

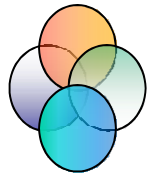
② Please pay more attention to the concepts, the method and the principle.

- Your aim is to learn something but not memorize.

③ Please finish the homework independently.

④ You'd better prepare for the course before every class time and review the course after every class time.

Conclusions



① Why we learn EMF
② The brief history of EMF
③ The main contains of EMF
④ How to learn EMF

Requirements

① Find some application examples related with EMF