General **BUT** very important considerations for a smooth course Ve230

Outline of the first part

- Introduction of the instructor and Teaching assistants
- Duties and obligations of the teacher
- Duties and obligations of the TA’s
- Duties and obligations of the Students
- The JI Honor code
- Class rules
- Homework's rules
- Quiz rules
- Exam rules
- Grading policy
- Schedule (Tentative)
- Teaching evaluation

VE230: Electromagnetism I

Professor

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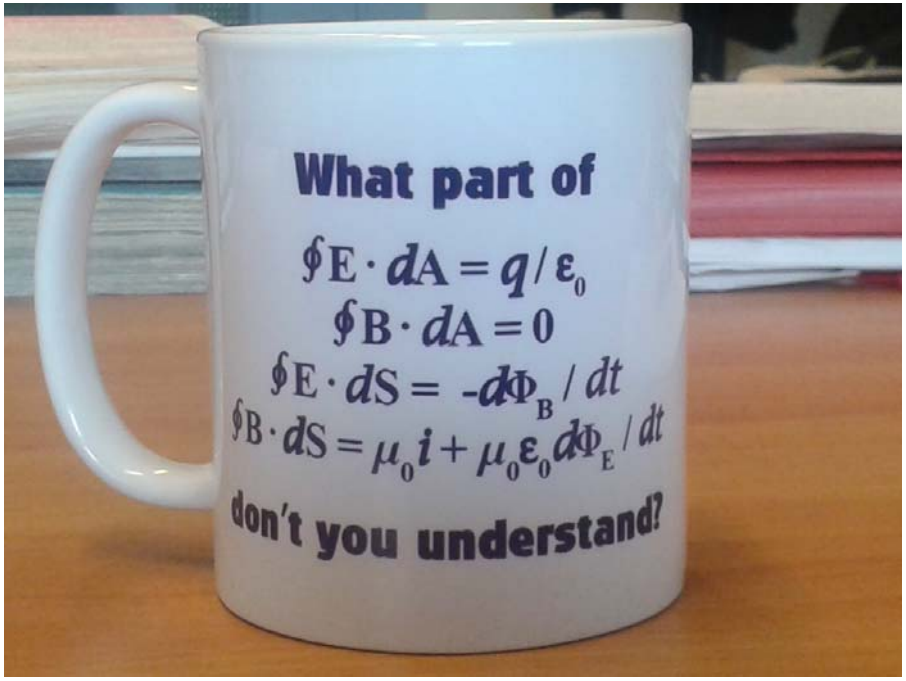


Duties and obligations of the teacher

Will give his best to let you not only learn, not only understand, not even only enjoy Ve230 but literally fall in love with physics

Does all what he could to remain concerned by your process of understanding

Office hours will be dedicated to your questions: be aware that these office hours **WILL NOT** be dedicated to help solving problems **BUT** to discuss conceptual questions that have been treated in class but not well understood
Schedules will be announced later this week

Duties and obligations of the TA's

Hold recitation classes: 90-120 minutes: **You are highly advised to attend !** Schedules will be announced later this week
Problems will be proposed and treated in order to strengthen the understanding of the concepts learned during classes

Grade homework's, quizzes and exam and release scores in Canvas:
In case of any conflict or complain quizzes and exam copies will be checked by the instructor

Duties and obligations of the Students

Work hard, enjoy and show that the instructor and TA's are not wasting their time
Do your best to make China, JI, Teacher and TA's proud of you

The JI Honor Code

Personal integrity as students and professionals

Respect other people and their work

Respect yourself and your own efforts

Mutual trust

Applicable to all your academic activities here, including homework, quizzes, projects and exams

Violations will be reported to the Honor Council

- Copy other student's homework, quizzes, exams
- Illegal copy of online resource and academic literatures
- Helping other on the abovementioned activities
- Fake ID for exams

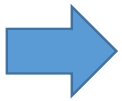
Class rules

- No food is allowed inside class. Anyone coming with food is requested to stay outside until finished eating
- Soft drink may be allowed

- Please do not arrive late and do not get up to leave until the class is dismissed or during the break.
  Action will be taken if a recurrent perturbation becomes obvious

- You are responsible for all material covered in class, whether or not it is in the books
  According to teacher's experience there is no dedicated book as any reference depends on the student "taste"

Books suggested by JI



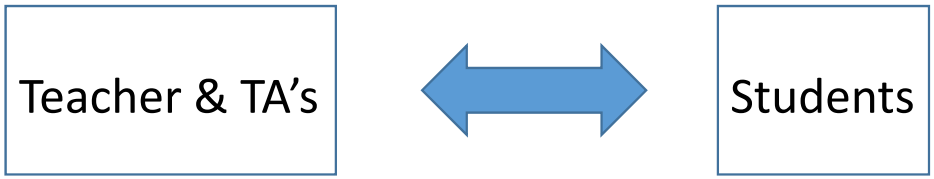
- Field and Electromagnetics(2nd Edition): **David K. Cheng**
- Introduction to Electrodynamics(3rd Edition): **David J.Griffiths**
- Fundamentals of Applied Electromagnetics (5th): **Fawwaz T. Ulaby**
- Electricity and Magnetism(3rd Edition): **Edward M. Purcell, David J. Morin**

About quizzes

- ***Unlike the exams, the dates for quizzes will not be announced !***
- ***Once the quiz is decided during the class NO STUDENT is allowed to get in !***

Interaction in Class

Physics is an interactive science  Requires live questions and comments



- There is **NO** <u>stupid</u> question: everybody should feel free to ask questions and make comments
- The questions can be asked along different forms
  - ✓ Directly during class allowing every body to benefit
  - ✓ By email for those who are shy: both the questions and answers will be given during the next lecture (for confidentiality purposes, the name of the student asking the questions will not be cited)

Gathering around the blackboard at the end of the lecture to ask questions prevent students to benefit from other's questions

Canvas

- Why the lecture will not be posted **BEFORE** given in class?

  Because I will be asking “star” questions for which the response are given in the slides

- It becomes thus useless to open the laptop during the class: **You lay take notes**

  Watching movies and football match during class is a total nonsense

About “star” questions

During each class some questions graded 1, 2 or 3 stars will be asked. The students who are volunteer and willing to answer, gain stars which at the end of the term may be of great help to improve their rank thus their GPA

The collected stars DO NOT enter into the calculation of the final score.
Lack of stars do not disadvantage the student BUT may greatly help some to jump to a higher grade (Bonus)
P, D, C^-, C, C^+, B^-, B, B^+, A^-, A, A^+

Vp260 versus Ve230

- Is it worth reminding some basic concepts learned in Vp260 while teaching Ve230?
- During the first 3 lectures questions refereeing to Vp260 will be asked
- Is it worth mentioning the names of the physicists who are at the origin of a concept?
  In other words, is a brief historical touch, as an approach of understanding physics, pertinent?
- If you encounter understanding difficulties don’t wait until a week before the final exam to start worrying

Homework rules

Homework will be assigned online on Canvas. They are usually due one week later, if not specified otherwise.

- One day automatic grace period
- Second day late penalty -20%
- Later no credit

Students should complete the homeworks independently. Copy of others' homework is not allowed and is considered as a violation to the Honor Code

Solutions will be posted on Canvas a week after the due date

Quiz rules

- There will be 3 in-class quizzes over the term
- Students should complete the quiz independently. No talk and collaboration are allowed
- **Closed books**
- No electronic devices except basic calculators will be allowed to use

Reminder about quizzes

- ***Unlike the exams, the dates for quizzes will not be announced !***
- ***Once the quiz is decided during the class NO STUDENT is allowed to get in !***

Exam rules

There will be two mid-term exams and one final exam. Each lasts **?????** minutes

Students should complete the quiz independently. No talk and collaboration are allowed

Closed books; 1 double sided sheet for each exam

No electronic devices except basic calculators will be allowed to use

Grading Policy

Homework	20%
Midterm I + II	20% + 25%
Final	30%
Quizzes	5%

A very important issue

How to solve problems during the exams

The way a problem is solved tells about the student's skill and his/her ability to be didactic.

Example of a problem given during summer term 2006

Problem 5 (15 pts)

A uniformly charged (thin) non-conducting rod is located on the central axis a distance b from the center of a uniformly charged non-conducting disk. The length of the rod is L and has a linear charge density λ. The disk has a radius R and a surface charge density σ.

- Calculate the total force between these two objects.
- What if the disk has an infinite diameter?

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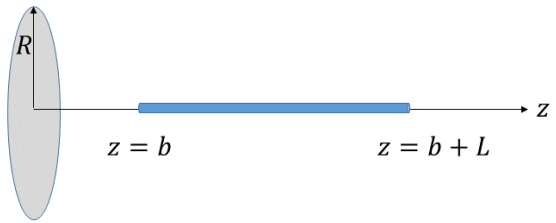


Student A

$$\vec{E} = \frac{\sigma}{2\varepsilon_0}\left[1 - \frac{1}{\sqrt{R^2/_{z^2} + 1}}\right]\vec{k}$$

$$d\vec{F} = dq\vec{E} \qquad dq = \lambda dz$$

$$\vec{F} = \int_b^{b+L} \frac{\sigma}{2\varepsilon_0}\left[1 - \frac{1}{\sqrt{R^2/_{z^2} + 1}}\right]\vec{k}.dq$$

$$\vec{F} = \frac{\lambda\sigma}{2\varepsilon_0}\left(L - \sqrt{R^2 + (b+L)^2} + \sqrt{R^2 + b^2}\right)\vec{k}$$

$$R = \infty, \vec{E} = \frac{\sigma}{2\varepsilon_0}\vec{k}$$

$$\vec{F} = \frac{\lambda\sigma L}{2\varepsilon_0}\vec{k}$$

Student B

We saw in class that the electric field created at any point along the central axis is given by

$$\vec{E} = \frac{\sigma}{2\varepsilon_0}\left[1 - \frac{1}{\sqrt{R^2/_{z^2} + 1}}\right]\vec{k}$$

It has only one component, along z −axis. Breaking up the rod into an infinite number of infinitesimally small point charges dq, We have that the net force on each tiny charge is $d\vec{F} = dq\vec{E}$. Summing up all these contributions, and using the fact that $dq = \lambda dz$ gives

$$\vec{F} = \int_b^{b+L} \frac{\sigma}{2\varepsilon_0}\left[1 - \frac{1}{\sqrt{R^2/_{z^2} + 1}}\right]\vec{k}.dq$$

Replacing $dq\ by\ \lambda dz$ and integrating gives,

$$\vec{F} = \frac{\lambda\sigma}{2\varepsilon_0}\left(L - \sqrt{R^2 + (b+L)^2} + \sqrt{R^2 + b^2}\right)\vec{k}$$

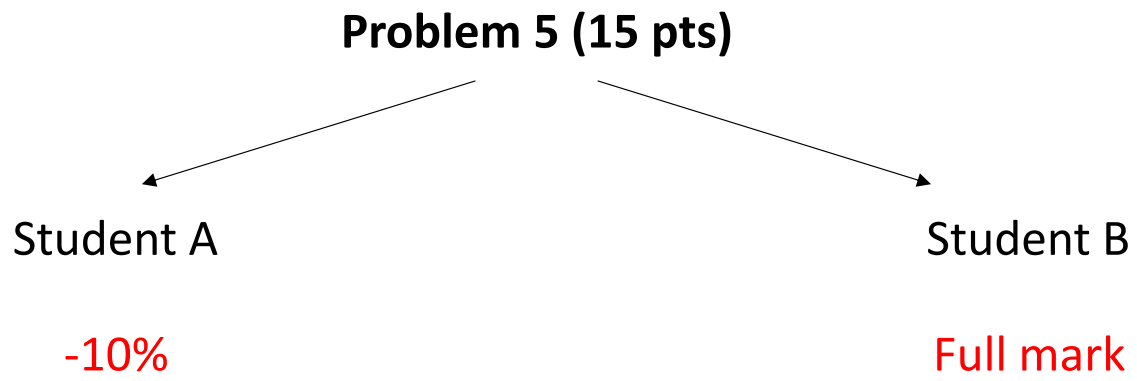
If the disk has an infinite diameter, the electric field simplifies and is now given by $\vec{E} = \frac{\sigma}{2\varepsilon_0}\vec{k}$ and the force is simply,

$\vec{F} = \frac{\lambda\sigma L}{2\varepsilon_0}\vec{k}$ or $\vec{F} = \frac{Q\sigma}{2\varepsilon_0}\vec{k}$ or $\vec{F} = Q\vec{\mathrm{E}}$,

where Q is the charge of the rod ($Q = \lambda L$).

Which way do you like ?

Be aware !



A student who does not explain what he/she is doing will **NOT get the full mark** even though the solution is correct

Schedule (Tentative)

Course Description: Vector calculus; Electrostatics; Magnetostatics; Energy and elementary circuits; Maxwell's equations; Plane waves.

Tentative Teaching Schedule:

Lecture 0. General consideration and learning versus understanding
Lecture 1. Introduction I: General overview of electromagnetism
Lecture 2. Introduction II: Defining concepts and principles
Lecture 3. Position of the problem and Vector Analysis I
Lecture 4. Vector Analysis II **HW1**
Lecture 5. Static Electric Fields: Work and potential energy
Lecture 6. Static Electric Fields: Gauss law and applications
Lecture 7. Static Electric Fields: Dipole
Lecture 8. Static Electric Fields: Conductor **HW2**
Lecture 9. Static Electric Fields: Dielectric I
No lecture, Midterm Exam 1
Lecture 10. Static Electric Fields: Dielectric II
Lecture 11. Static Electric Fields: Electrostatic energy and force
Lecture 12. Steady Electric Currents: Ohm's and Kirchhof's law **HW3**
Lecture 13. Steady Electric Currents: Joule's law

Lecture 14. Magnetostatics I: Basic of magnetic field force and its applications
Lecture 15. Magnetostatics II: Ampere's law and its applications
Lecture 16. Magnetostatics III: Vector potential and its applications
Lecture 17. Magnetostatics IV: Faraday's emf induction **HW4**
Lecture 18. Static Magnetic Fields: Electrostatic versus magnetostatics
No lecture, Midterm Exam 2
Lecture 19. Maxwell's Equations I: Electromagnetic waves
Lecture 20. Solving Maxwell's equations in free space
Lecture 21. Solving Maxwell's equations with current and charges **HW5**
Lecture 22. Plane Electromagnetic Waves I
Lecture 23. Plane Electromagnetic Waves II
Lecture 24. Plane Electromagnetic Waves III
Lecture 25. Plane Electromagnetic Waves IV **HW6**
Lecture 26. Plane Electromagnetic Waves V
Lecture 27. From Maxwell to Einstein: Does special relativity fit with Maxwell's equations?
Review
No lecture, Final Exam

Schedule (Tentative)

Introduction and Vector analysis	2 weeks
Electrostatics	4 weeks
Magnetostatics	4 weeks
Maxwell's equations	2 weeks
Plane wave propagation	1 weeks
Review and exams	1 weeks

2 lectures and a half per week

Recitation classes and office hours

TA's

Office hours

- Tuesday 8.00-10.00 p.m. by Li Chunchao
- Thursday 8.00-10.00 p.m by Ziling Yuan

Recitation classes

- Wednesday 2-3:40 pm by Ziling Yuan
- Thursday 6.20-8.00 pm by Li Chunchao

Instructor

Office hours: Room 216, JI building

- Monday or Tuesday 10:00 to 12:00 am

About star questions

No deduction is applied to those who do not participate in class !

BUT participating in class, through star questions from the instructor, comments and questions from the studends etc… helps !

Whether the "star question" issue is taken into account before or after the curving process is not decided yet

Teaching Evaluation

"The IDEA Center is a nonprofit organization whose mission is to serve colleges and universities committed to improving learning, teaching, and leadership performance. The Center supports the evaluation and development of both programs and people."

My job: to participate this program to improve my teaching.

Your job: to fill out some forms as requested over the semester.

Reasons for being concerned by Teaching evaluation

- In any institution and in any society, the goal is to improve the conditions for a better life
- Our grandparents and parents worked hard to allow us get educated: They paved the way to us
- It is crucial today to feel concerned by the coming generations, your brothers, sisters, neighboors and friends
- My presence here cost money to China, therefore to your parents. That is why, you need to make sure and claim whether my teaching is relevant or not to the future of China
- You are not allowed to miss the possibility to participate in evaluating your teacher, whether Chinese or foreigner

Feeling concerned makes you real citizens

This is the only way for JI to continue offering a high standard education to Chinese pupils

Learning versus understanding

Why is it so important that you <u>understand</u> something instead of just <u>learning</u> a thing?

- **Learning** = act of memorization of a set of supposed facts

  ⇨ Apply them in a very limited and focused manner to solve problems

- **Understanding** = Makes us able to correlate a whole bunch of concepts in order to come up with a <u>holistic</u> comprehension

<u>Holistic:</u> Characterized by the belief that the parts of something are intimately interconnected and explicable only by reference to the whole.

- It is up to you to decide whether physics is right or wrong
- Anyone who tries to convince you that physics is beyond question is someone who truly does not ‘understand’ what he or she is talking about
- Physics could be partly right and partly wrong, it could also be totally doubtful to you
- Your subjective world is as important as any objective truth that is expounded by anyone else.

Understanding is the act of questioning what you have learned

Without this act…

- ***Planck would not have come up with quantum physics***
- ***Maxwell would not have come up with his theory of electromagnetism***
- ***Einstein would have come up with his relativity theory***

Learning makes you knowing ***BUT*** *understanding makes you skilled*

Understanding physics

The understanding process is settled in a logical order following somehow the historical path

- Nowhere the students start by learning relativity theory or quantum physics before getting acquainted with classical Newtonian mechanics

- **Are the concepts learned in classical mechanics obsolete in learning another field (electromagnetism)?**

  - ✓ Force and acceleration
  - ✓ Potential and kinetic energy
  - ✓ Conservation laws: Energy – linear and angular momentum etc…

- The concept of **Force** was still used in Bohr's atom model **BUT** no longer in quantum mechanics
- All other concepts are not only valid! **They have been strengthened**

In electromagnetism all what has been learned in Classical mechanics is crucial

The physical word is very broad

Great principles apply to **ALL** different kinds of phenomena

Conservation laws
Principle of least action
⋮

Many seemingly complicated phenomena may reduce to understanding what happens at the atomic scale

Electricity may help understanding compression of solids
⋮

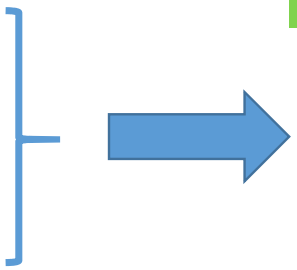
The most remarkable thing

- Equations for <u>many different physical situations have exactly the same form</u> ⇨ lead to the same solution
- Understanding one situations may greatly facilitate understanding others

**Question #1

Example 1: What is common to the following physical situations?

- A stone thrown in a lac
- A loud speaker emitting sound
- A light source emitting light
- A beam of material particles hitting a crystal
- An electron orbiting in an atom



Answer to **Question #1

They all obey a wave equation and produce interferences

We can see a mechanical wave but nobody has ever seen a light wave

**Question #2

How did we came to the facts that:

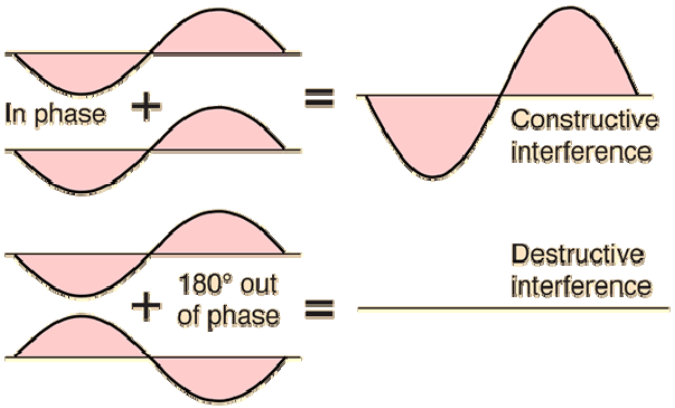
- Light is a wave
- Light is made of particles called photons?

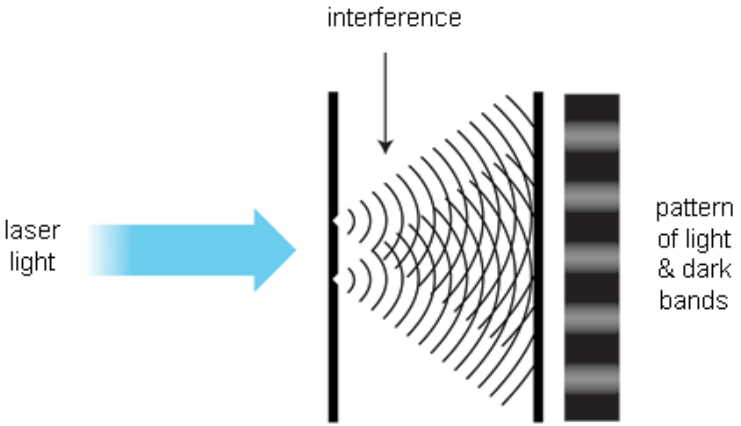
Answer to **Question #2

Light as a wave: Classical electromagnetism (Maxwell's theory)

- Interference = distribution in space of constructive and destructive patterns ⇒ adding things :

  ✓ Enforced
  ✓ Weakened





Light as a particle: quanta exchange between light and matter
Photoelectric effect (Hertz experiment vs Einstein explanation)

Example 2: Electrostatic versus other things

Electrostatic

$$\vec{\nabla}.(\varepsilon_r\vec{E}) = \frac{\rho}{\varepsilon_0} \qquad \vec{\nabla}\times\vec{E} = 0 \qquad \vec{E} = -\vec{\nabla}\varphi \qquad \vec{\nabla}.(\varepsilon_r\vec{\nabla}\varphi) = -\frac{\rho}{\varepsilon_0}$$

$\vec{E}$ Electric field
φ Electric potential
ε_r, ε_0 Dielectric constants
ρ charge density

Flow of heat

$$\vec{\nabla}.\vec{h} = s \qquad \vec{h} = -K\vec{\nabla}T \qquad \vec{\nabla}.(K\vec{\nabla}T) = -s$$

$\vec{h}$ heat flow
s heat energy/unit volume
K thermal conductivity

Stretched membrane

$$\vec{\nabla}.(\tau\vec{\nabla}u) = -f$$

τ Surface tension
u vertical displacement of the membrane
f = upward force per unit area

Diffusion of neutrons

$$\vec{\nabla}.\vec{J} = S - \frac{\partial N}{\partial t} \qquad \vec{J} = -D\vec{\nabla}N \qquad \vec{\nabla}.(D\vec{\nabla}N) = \frac{\partial N}{\partial t} - S$$

$N(x,y,z,t)$ = number of neutrons in volume element
S rate of neutron generation
D diffusion constant

Important thing

Rate of change of physical quantity with position and time

- Scalar field
- Vector field

Fundamental laws

Tool box #1

- Differential equations
- Integral equations

Tool box #2

- Gradient
- Divergence
- Curl

… require specific mathematical tools and spatial representation

+ An important ingredient : **Symmetry**
+ An important principle : **Superposition**

Understanding and solving equations

What does it really mean “Understanding an equation” ?

Dirac: *“I understand what an equation means if I have a way of figuring out the characteristics of its solutions without actually solving it”*

***Question #3

What do these two equations describe and what do they tell us about physics?

Answer to ***Question #3

Wave equation $\frac{\partial^2 u}{\partial t^2} = v^2 \frac{\partial^2 u}{\partial x^2}$

Heat equation $\frac{\partial u}{\partial t} = \alpha \frac{\partial^2 u}{\partial x^2}$

1) Both indicate that something propagates ⇔ changes position with time

2) The first equation says that energy is conserved and time is reversible

3) The second equation tells that energy dissipates and time is irreversible

$t \rightarrow -t$

Historical time dependent key elements to Maxwell's equations

Electro/magneto/statics

Electrodynamics

time

Coulomb (1785)

$\vec{E} \propto \frac{q}{r^2}\vec{u}_r$

$\vec{E} \,//\, \vec{u}_r$

$\propto \frac{1}{r^2}$

Poisson (1813)

$\vec{E} = -\vec{\nabla}\varphi$

$\nabla^2\varphi = -\frac{\rho}{\varepsilon_0}$

Orsted (1820)

$\vec{J} \rightarrow \vec{B}$

Biot and Savart (1820)

$\vec{J} \rightarrow \vec{v} \times \vec{r} \rightarrow \vec{B}$

Ampere (1820)

$\vec{\nabla} \times \vec{B} = \frac{1}{c^2}\frac{\vec{J}}{\varepsilon_0}$

$\propto \frac{1}{r^2}$ $\vec{B} \perp \vec{u}_r$

Faraday (1821)

$\frac{\partial B}{\partial t} \rightarrow E(t) \rightarrow \vec{J}$

$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$

Gauss (1831)

Concept of flux

$\vec{\nabla}.\vec{E} = \frac{\rho}{\varepsilon_0}$

$\vec{\nabla}.\vec{B} = 0$

Perfect symmetry far from the source

Maxwell (1873)

$D = \varepsilon_0 E \rightarrow \frac{\partial E}{\partial t} \rightarrow \frac{\partial D}{\partial t} = j$

Displacement current

Ampere + Maxwell

$\vec{\nabla} \times \vec{B} = \cancel{\frac{1}{c^2}\frac{\vec{J}}{\varepsilon_0}} + \frac{1}{c^2}\frac{\partial \vec{E}}{\partial t}$

EM waves

$\vec{E} \perp \vec{B} \perp \vec{u}_r$ $\propto \frac{1}{r}$

Discovery of Maxwell letting him to the Electromagnetic wave equation

- At his time physics seemed complete
  ⇨ Was he to refrain from asking himself questions
  and therefore concentrate just on **learning** instead of **understanding**?

- The equations of electrostatic and magnetostatic where mutually inconsistent when put together

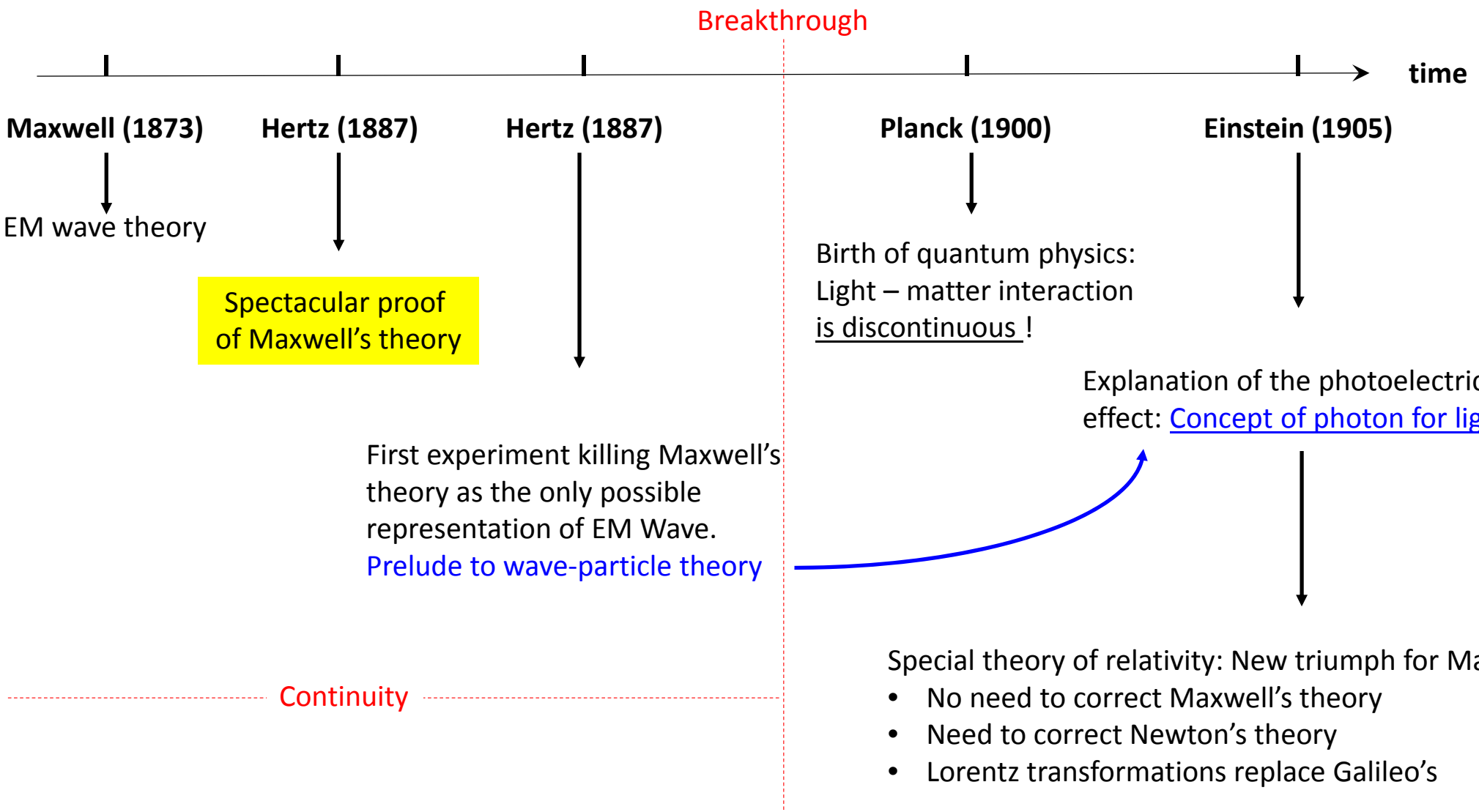
- Maxwell added a new term to Ampere's law

An amazing thing appeared

Part of electric and magnetic fields fall off as $\mathbf{1/r}$ **AND** $\vec{E} \perp \vec{B} \perp \vec{u}_r$

Much slowly than $\mathbf{1/r^2}$ law of Coulomb and Biot & Savart law

Electromagnetic waves were predicted


Breakthrough
time
Maxwell (1873)
Hertz (1887)
Hertz (1887)
Planck (1900)
Einstein (1905)
EM wave theory
Spectacular proof of Maxwell's theory
Birth of quantum physics: Light – matter interaction is discontinuous !
Explanation of the photoelectric effect: Concept of photon for light
First experiment killing Maxwell's theory as the only possible representation of EM Wave. Prelude to wave-particle theory
Continuity
Special theory of relativity: New triumph for Maxwell
• No need to correct Maxwell's theory
• Need to correct Newton's theory
• Lorentz transformations replace Galileo's