

Transformed E&M I materials

Electric Field, Coulomb's Law (Griffiths Chapter 2)

TIMELINE

Prof A covers this in lectures 5.

Prof B. covers this in lecture 2-3

Transformed course covered in lectures 2-3.

LEARNING GOALS

1. Students should be able to state Coulomb's Law and use it to solve for E above a line of charge, a loop of charge, and a circular disk of charge.
 2. Students should be able to solve surface and line integrals in curvilinear coordinates (when given the appropriate formulas, as in the inner-front cover of Griffiths).
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CLASS ACTIVITIES

Coulomb

Tutorials

Lab 1 – Intro to Electrostatics

Griffiths by Inquiry

Whiteboard

Integral for E for line of charge

Work out the integral for the example of the E from a finite line of charge, with constant lambda. This is practice in constructing "script R", mostly.

Discussion

Questions for Lecture (from UIUC)

1. Is Coulomb's force law valid for all separation distances r_{ab} ? Is it valid for $r_{ab}=0$?
2. What is the physics origin of the $1/r^2$ dependence of Coulomb's force law? Of the $1/\epsilon_0$ dependence? Of the $1/4\pi$ factor?
3. What really is electric charge? What is the equivalent of "charge" for any/all of the 4 fundamental forces of nature?
4. Why is electric charge quantized (in units of e)? What operative physics dictates this?
5. What really is negative vs positive electric charge (i.e., $-e$ vs $+e$)?
6. Why does the Coulomb force vary as the product of two electric charges?
7. What is a macroscopic vector field, such as $\mathbf{E}(\mathbf{r},t)$?
8. Are electric field lines real? Do they really exist in space and time?

See Activities/Activity resources "Deep Questions" for answers to these questions.

Tutorials

Electric Field due to a Ring of Charge

Oregon State University

In this activity, students working in small groups to write the electric field in all space due to a charged ring. The groups are then asked to expand this potential in a series, either on the axis or the plane of symmetry, and either close to the center of the charge distribution or far away.

Charge distributions

Kinesthetic activity

Line Charge

Oregon State University

Asked about 6-10 students to stand up. "Make a linear charge density for me, a lambda". Then, lots of discussion and other variations - Make lambda bigger. Is this really a lambda, or an approximation? What if the charges were only on your heads, is that more "lambda-like". In what way(s)? Does it matter that the charges are coming in chunks, does THAT make it "not a line charge"? Make it nonuniform. Make it curl around - is it still a lambda?)

Tutorial

Two-dimensional charge distributions

Paul van Kampen – Dublin University (Tutorials 1-8, page 25)

Two dimensional charge distributions. Practice in integration in polar coordinates. Calculate net charge on a disk, the problem is broken into pieces (find dA , write dQ , write out the integral, evaluate), and then do it again in Cartesian.

Computer visualizations

E-field, Charge distributions, line and surface integrals

Electric field lines of various charge distributions, including the ability to do line and surface integrals to determine circulation and flux:

<http://www.falstad.com/mathphysics.html>

2D electrostatics: <http://www.falstad.com/emstatic/>

2D electrostatic fields: <http://www.falstad.com/vector2de/>

3D electrostatic fields: <http://www.falstad.com/vector3de/>

Discussion

Deep Questions

Some "deep questions" discussed (e.g., WHY is Coulomb $1/r^2$, WHY is it the product of charges. What IS charge anyway? Opened this up to them, let them discuss a little, some questions we can/will address - like $1/r^2$ in coulomb.

Others, perhaps not, like "what is charge")

Whiteboards

Concept Map of Physics

Passed out white boards - (brief discussion of "how and why") Concept map of physics on white board. Everyone does it on their own, then share with neighbors. What is physics? Think of the BIG ideas, and then organize them (connect the parts that need connecting - perhaps the connections themselves have names...) It can be by courses, topics, ideas, whatever you think represents the whole world of physics on one whiteboard!