

PHYS 1441 – Section 001

Lecture #5

Monday, June 13, 2016

Dr. Jaehoon Yu

- Chapter 22
 - Electric Flux
 - Gauss' Law with many charges
 - What is Gauss' Law good for?
- Chapter 23 Electric Potential
 - Electric Potential Energy

Today's homework is homework #3, due 11pm, Wednesday, June 15!!

Monday, June 13, 2016



PHYS 1444-001, Summer 2016
Dr. Jaehoon Yu

Announcements

- Reading assignments
 - CH22.4



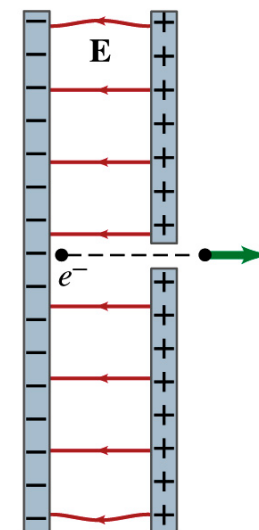
Reminder: Special Project #2 – Angels & Demons

- Compute the total possible energy released from an annihilation of x -grams of anti-matter and the same quantity of matter, where x is the last two digits of your SS#. (20 points)
 - Use the famous Einstein's formula for mass-energy equivalence
- Compute the power output of this annihilation when the energy is released in x ns, where x is again the first two digits of your SS#. (10 points)
- Compute how many cups of gasoline (8MJ) this energy corresponds to. (5 points)
- Compute how many months of world electricity usage (3.6GJ/mo) this energy corresponds to. (5 points)
- Due by the beginning of the class Thursday, June 16.



Special Project

- **Particle Accelerator.** A charged particle of mass M with charge $-Q$ is accelerated in the uniform field E between two parallel charged plates whose separation is D as shown in the figure on the right. The charged particle is accelerated from an initial speed v_0 near the negative plate and passes through a tiny hole in the positive plate.
 - Derive the formula for the electric field E to accelerate the charged particle to a fraction f of the speed of light c . Express E in terms of M , Q , D , f , c and v_0 .
 - (a) Using the Coulomb force and kinematic equations. (8 points)
 - (b) Using the work-kinetic energy theorem. (8 points)
 - (c) Using the formula above, evaluate the strength of the electric field E to accelerate an electron from 0.1% of the speed of light to 90% of the speed of light. You need to look up the relevant constants, such as mass of the electron, charge of the electron and the speed of light. (5 points)
- Due beginning of the class Monday, June 20

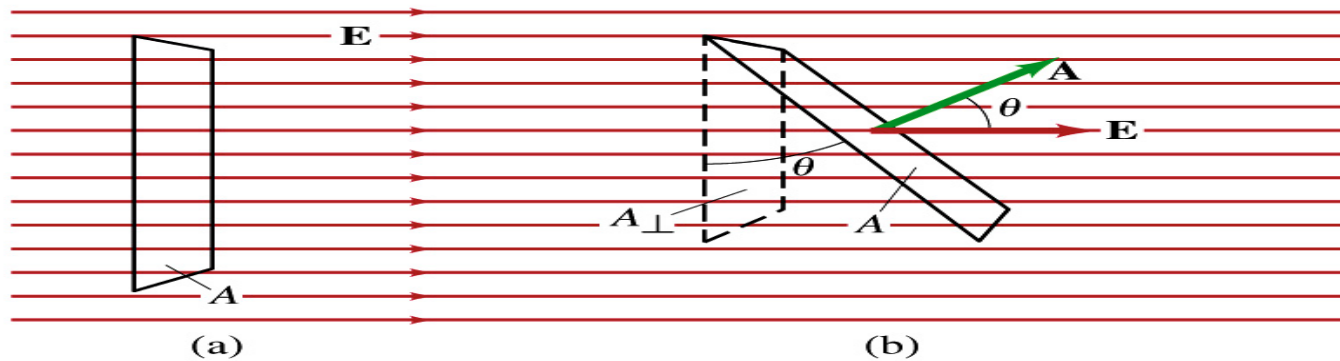


Gauss' Law

- Gauss' law states the relationship between electric charge and the electric field.
 - More generalized and elegant form of Coulomb's law.
- The electric field by the distribution of charges can be obtained using Coulomb's law by summing (or integrating) over the charge distributions.
- Gauss' law, however, gives an additional insight into the nature of electrostatic field and a more general relationship between the charge and the field



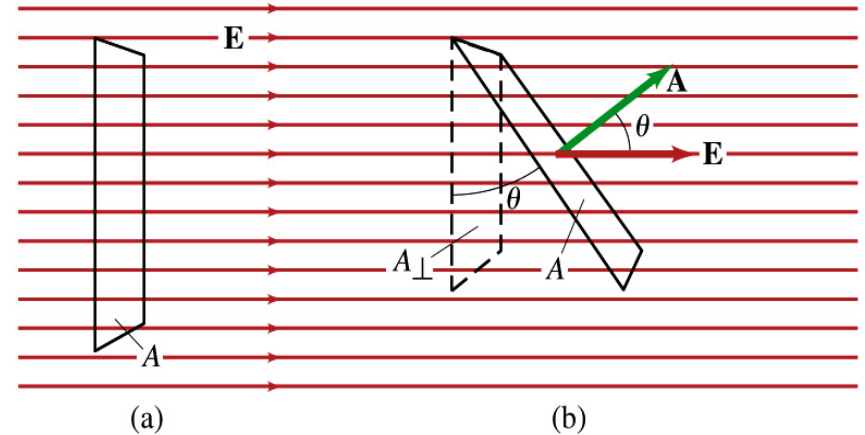
Electric Flux



- Let's imagine a surface of area A through which a uniform electric field E passes
- The electric flux Φ_E is defined as
 - $\Phi_E = EA$, if the field is perpendicular to the surface
 - $\Phi_E = EA \cos \theta$, if the field makes an angle θ to the surface
- So the electric flux is defined as $\Phi_E = \vec{E} \cdot \vec{A}$.
- How would you define the electric flux in words?
 - The total number of field lines passing through the unit area perpendicular to the field. $N_E \propto EA_{\perp} = \Phi_E$

Example 22 – 1

- Electric flux.** (a) Calculate the electric flux through the rectangle in the figure (a). The rectangle is 10cm by 20cm and the electric field is uniform with magnitude 200N/C. (b) What is the flux in figure if the angle is 30 degrees?



The electric flux is defined as

$$\Phi_E = \vec{E} \cdot \vec{A} = EA \cos \theta$$

So when (a) $\theta=0$, we obtain

$$\Phi_E = EA \cos \theta = EA = (200 \text{ N/C}) \cdot (0.1 \times 0.2 \text{ m}^2) = 4.0 \text{ N} \cdot \text{m}^2 / \text{C}$$

And when (b) $\theta=30$ degrees, we obtain

$$\Phi_E = EA \cos 30^\circ = (200 \text{ N/C}) \cdot (0.1 \times 0.2 \text{ m}^2) \cos 30^\circ = 3.5 \text{ N} \cdot \text{m}^2 / \text{C}$$