Quizzes (Fall 2021)

PHYS 205B: University Physics

Due date: At 9:30 AM before each class, on D2L

Instructions

- Assessment of quizzes does not look for correctness. Instead, it expects you to be critical and creative.
- The questions are often left open ended. Thus, it is not recommended to spend more than ten minutes on a question. You are encouraged to ponder about it though.
- After completion, scan the pages as a single PDF file, and submit the file on D2L (under Assessments → Assignments).

Questions

Chapter 23:

(**Q-0817:**) Is the following statement true? There exists no electric forces between atoms because atoms are neutral.

(**Q-0819:**) The electric field due to a uniformly charged solid sphere of radius R at a distance $r > R$ from the center of the sphere is given by

$$\mathbf{E} = \hat{\mathbf{r}} \frac{1}{4\pi\varepsilon_0} \frac{Q}{r^2}, \qquad r > R, \tag{1}$$

where Q is the total charge on the sphere and $\hat{\mathbf{r}}$ specifies the direction of the electric field to be pointing radially outwards. Observe that the electric field outside the sphere is independent of the radius of the sphere. Thus, in principle, one could even take the limit $R \to 0$ representing a point particle. With this information, inquire what is the radius of electron. (Do not confuse this with the classical radius of a electron, which is just a physical constant.)

(**Q-0824:**) Electric field lines is a visual representation of electric field.

(a) How does one (visually or qualitatively) read out the direction and magnitude of electric field (at a point) from the associated electric field lines?

(b) Can two lines in the electric field lines for a configuration of charges intersect? If yes, give an example, otherwise, why not?

(c) Draw the electric field lines for a configuration consisting of three identical positive charges placed at the corners of an equilateral triangle. Qualitatively, read out the points where the field lines go to zero. There are how many such points? Look up the answer in the literature, which might surprise you.

(d) Do the electric field lines at the center of the equilateral triangle in the above configuration intersect? Explain.

(**Q-0826:**) Vertical wind shear displaces postive charges from the ground to clouds. Thus, the clouds and the ground can be modeled as oppositely charged parallel plates. When the electric field generated by this configuration is about 10^5 N/C or more, it can strip the charges inside an atom. This triggers an avalanche, which is the phenomenon of lightning. This is called electric breakdown of air. That is, air ceases to be an insulator when the electric field exceeds a critical value. Look up the difference between positive lightning and negative lightning.

(**Q-0831:**) Watch the following YouTube video by Physics Girl

https://youtu.be/ot4_jVFXxUU

on Faraday cage. Based on this idea explain why your phone coverage is spotty inside concrete buildings.

(**Q-0902:**) Draw equipotential surfaces for the following configurations.

(a) Single point charge.

(b) Two positive charges of equal magnitude.

(c) Three positive charges of equal magnitude placed at the corners of an equilateral triangle.

(**Q-0909:**) What is connection between the concept of electric potential difference and concept of voltage in electrical circuits? What is the relevance of ground in electrical circuits?

(**Q-0914:**) A tube light glows when brought close to a van de Graaff generator. The dome of a van de Graaff generator is a charged sphere, with eectric charge collected on the dome using a moving belt. A charged sphere creates a potential difference radially outwards around it. Can you use this procedure to generate potential differences to power your phone? In other words, how can you harness energy from static electricity generated due to friction?

(**Q-0916:**) A capacitor is a device that has the ability to store electrical energy. It is stored in the form of electric field that is confined inside the capacitor. A supercapacitor is a capcitor with capacitance hundred times larger than traditional capacitors. Explore the labs in SIUC that do research on supercapacitors. You could start from this link.

(**Q-0921:**) Watch the following YouTube video by National High Magnetic Field Laboratory in Florida,

https://youtu.be/5hFC9ugTGLs,

on capacitors. Recall the definition of power as energy per unit time. Then, inquire if capacitor is employed for operations requiring high power or low power. Imagine processes where you would employ a capacitor over a battery.

(**Q-0923:**) Watch the following YouTube video by Higgsino Physics,

https://youtu.be/h6FYs_AUCsQ,

on superconductors. Ohm's law is applicable for normal conductors and superconductors are instead described by London equation. What is the resistance of a superconductor?

(**Q-0928:**) Watch the following YouTube video created by students in MIT,

https://youtu.be/-G-dySnSSG4,

on Wheatstone bridge. It illustrates how measuring differences in a quantity can reduce the error in a measurement. The Wheatstone bridge and its extended version, the Kelvin bridge, is especially useful for measuring small resitances accurately. Imagine situations where you would employ a Wheatstone bridge.

(**Q-0930:**) Direct Current (DC) versus Alternating Current (AC), what is the difference?

(**Q-1007:**) Aurora Borealis (northern lights) and Aurora Australis (southern lights) is a spectacular display of light shimmering across the night sky, often observed around magnetic poles of the Earth, when charged particles emitted by the Sun and guided along by the magnetic field of the Earth enter the atmosphere. Check out an animation of this phenomenon as seen from space, released by NASA Earth Observatory,

Aurora Australis on 2005 Sep 11,

which to an observer on Earth would appear as a curtain of shimmering light. Where is the magnetic north pole?

(**Q-1012:**) A charged particle in a magnetic field goes in circles (or in helices). Recall that positron is the antiparticle of electron. Describe the motion of a positron in a magnetic field, and contrast it to that of an electron in a magnetic field. How will the ionization track of electron and positron differ in a bubble chamber? For example, refer to the picture at 34:21 minute in the lecture by Frank Close, part of

Christmas Lectures, 1993.

(**Q-1014:**) Watch the following YouTube video by Institute for Quantum Computing,

https://youtu.be/SpZqmZPtj9I,

in which Professor Steven Girvin explains the classical Hall effect and the quantum Hall effect. How much is the Hall resistance (in ohms)? Research on topics discussed by Girvin are carried out in Prof. Mazumdar's laboratory at SIUC physics department.

(**Q-1019:**) The following YouTube video by New Scientist,

https://youtu.be/BREcwTXc6O4,

attempts to illustrate the idea of a magnetic monopole. It arises from the simple notion that a 'North pole' could be separated from it's 'South pole'. What will be the SI unit of magnetic charge if it were to exist?

(**Q-1021:**) Electric field $\mathbf{E}$ is a manifestation of change in electric potential V,

$$\mathbf{E} = -\boldsymbol{\nabla} V. \tag{2}$$

Is there a potential associated to the magnetic field?

(**Q-1026:**) The following YouTube video by Thomas Stevenson,

https://youtu.be/Y18N-hi5P1o,

explains Faraday's law of induction. Using a schematic diagram illustrate how this concept is used in converting wind energy into electrical energy?

(**Q-1028:**) In the following YouTube video,

https://youtu.be/k2RzSs4_Ur0,

William Berner, University of Pennsylvania, illustrates Lenz's law. Why doesn't the ring slow down when it is cut?

(**Q-1104:**) List the challenges associated with wireless energy transmission.

(**Q-1109:**) Using the opacity of electromagnetic waves as a function of the wavelength of eleactromagnetic waves presented in the following link

Wikipedia: Opacity of atmosphere to electromagnetic waves

argue that an X-ray telescope has to be necessarily installed above the atmosphere in space. Further, discuss radio-wave astronomy and gamma-ray astronomy.

(**Q-1116:**) Using plane mirrors alone design a setup that will allow you to see the back of your head.

(**Q-1118:**) In the following YouTube video,

https://youtu.be/GAmWs6zfTj8,

John Howell, Professor of Physics at the University of Rochester, explains a simple cloaking device using four plane mirrors. What are the challenges in designing a cloaking device?

(**Q-1130:**) What property of an object at the atomic scale contributes to the index of refraction?

(**Q-1202:**) Explain why light seems to be bending in the following YouTube video by Harvard Natural Sciences Lecture Demonstrations,

https://youtu.be/XrWB0KLXpn8.