Quizzes (Spring 2024)

PHYS 205B-002: UNIVERSITY PHYSICS

School of Physics and Applied Physics, Southern Illinois University–Carbondale

Due date: At 4:00 PM before each class, on D2L

Instructions

- This document collects the quizzes for the complete semester. One question below is due on each day of lecture.
- Assessment of quizzes does not look for correctness. Instead, it expects you to be critical and creative.
- The questions are conceptual. They might be 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). The question number syntax Q-MMDD is derived from date.

Questions

Electric charge and electric forces

(**Q-0118:**) Watch the following YouTube video by Bruce Yeany

https://youtu.be/jcoTqhXehDQ
https://youtu.be/U6bKDaZiy_k

to gain insight on how we can manipulate the electric charges in materials. Explain the demonstration using the idea of transfer of charges.

(**Q-0123:**) A charged conducting sphere is brought close to another neutral conducting sphere. (The spheres are not allowed to touch.) Is the electric force between the spheres zero? If not, is the force attractive or repulsive?

Check out the following presentation at Jefferson Lab,

https://youtube.com/embed/n3tauzN6-Uk?start=150&end=332,

that demonstrates this efect between timestamps 2:30 to 5:32 minutes.

Electric field

(**Q-0125:**) The following is a video illustrating the idea of Faraday cage in the SPARK Museum of Electrical Invention in Bellingham, Washington,

https://youtu.be/uAJfw3tALbI.

A perfect Faraday cage shields one from electric force. Imagine ways to shield from gravitational force.

(**Q-0130:**) The following is a short 3D animation from the Physics and Astronomy Animation Project at Penn State Schuylkill,

https://youtu.be/LB8Rhcb4eQM

Sketch the electric field lines of three identical positive charges at the corners of an equilateral triangle. Repeat the exercise after you replace one of the positive charge with a negative charge.

Continuous charge distributions and Gauss's law

(**Q-0201:**) The following 30 minute video produced by The Physical Science Study Committee (PSSC) on Coulomb's law,

https://youtu.be/o1kKGeLE1xI,

is presented by Eric M. Rogers from Princeton University. In particular, watch the the segement around timestamp 23:25 and discuss how a null force on a charge inside a spherical conductor is a verification of the inverse square law.

(**Q-0206:**) Watch the last ten minutes of Prof. Walter Lewin's lecture on Gauss's law,

https://www.youtube.com/watch?v=Zu2gomaDqnM&t=2498s.

Why does a ping-pong ball bounce back and forth in between two parallel oppositely charged plates?

Next, contrast the electric field distribution for the following configurations.

(a) Consider a spherically symmetric, uniformly charged, solid conducting sphere of radius R. What is the electric field inside the sphere? What is the electric field outside the sphere?

(b) Consider a spherically symmetric, uniformly charged, conducting spherical shell of radius R. What is the electric field inside the sphere? What is the electric field outside the sphere?

(c) Consider a spherically symmetric, uniformly charged, solid, dielectric sphere of radius R. Is the electric field inside the sphere zero? What is the electric field outside the sphere?

(d) Consider a spherically symmetric, uniformly charged, dielectric spherical shell of radius R. What is the electric field inside the sphere? What is the electric field outside the sphere?

Electric potential

(**Q-0208:**) Draw equipotential surfaces for the following configurations.

(a) Single point charge.

(b) Two positive charges of equal magnitude.

Then, attempt drawing equipotential surfaces inside a uniformly charged spherical shell. Are equipotential surfaces always surfaces?

(**Q-0213:**) A tube light glows when brought close to a van de Graaff generator. Electric charge from friction is collected on the dome of a van de Graaff generator using a moving belt. Watch the last five minutes of Prof. Walter Lewin's lecture on electric potential,

https://youtu.be/QpVxj3XrLgk.

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?

Capacitance

(**Q-0220:**) Watch the following video by Khan Academy,

`https://youtu.be/u-jigaMJT10`,

on capacitors and capacitance. For the same amount of voltage applied how does the geometry (size) of the capacitor determine the charge stored in the capacitor?

(**Q-0222:**) 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.

DC Circuits

(**Q-0227:**) 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-0229:**) 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.

Magnetic force

(**Q-0305:**) 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-0307:**) Plate tectonics explains the spreading of sea floor and periodic magnetic reversals on the sea floor. The following YouTube videos

https://youtu.be/JJEZ3Vizdww
https://youtu.be/BCzCmldiaWQ

explains this. What is the implication of the observation that the magnetic reversals on the sea floor have distinct boundaries and are not varying continuously?

(**Q-0319:**) 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?

Magnetic field

(**Q-0326:**) 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-0328:**) Two infinitely long straight wires parallel to each other carry steady currents I in each of them in the same direction as shown in Figure 1. Draw the magnetic field lines around the wires.

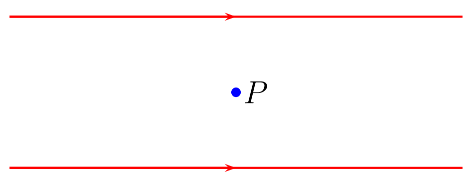

Figure 1: Two parallel current carrying wires.

Ampère's law

(**Q-0402:**) The following YouTube video by NOVA PBS Official,

https://youtu.be/w3zCZEouYx4,

explains the origins of the magnetic field of sun. How could Ampère's law help in the investigation of a complicated magnetic field distribution in space?

Faraday induction

(**Q-0404:**) 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-0409:**) 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?

Inductance

(**Q-0411:**) The following video,

https://youtu.be/RNqEyfVrEug,

is a demonstration of wireless power transmission by NASA. List the challenges associated with wireless power transmission. Briefly explain the working mechanism of wireless charging stations for phone and induction stove.

Electromagnetic waves

(**Q-0416:**) [(Atmospheric windows)] In the following links,

Wikipedia	:	Opacity of atmosphere to electromagnetic waves,
NASA Science	:	Atmospheric windows,
NASA Science	:	Electromagnetic spectrum,

find a plot of the opacity of Earth's atmosphere as a function of the wavelength of eleactromagnetic waves.

- Argue that an X-ray telescope has to be necessarily installed above the atmosphere in space. Further, discuss if radio-wave astronomy can be land based. What about gamma-ray astronomy?
- A living organism on Earth takes advantage of an available ecological niche. Then, ponder, why hasn't any organism evolved to communicate using radio waves. Could it be because of our aquatic origins, because water is opaque to radio waves, or is there a more fundamental chemical or biological limitation.

Find the absorption spectrum of water in the following links,

Brittanica	:	Absorption coefficient of liquid water,
Wikipedia	:	Absorption spectrum of liquid water.

(Inverse of absorption coefficient is a measure of how deep the wave will travel in water before getting absorbed.)

- Argue that kilometer long waves (extremely low-frequency waves) are suitable candidates for communications between a land base and submarines.
- Ponder if life on Earth seems to have exploited the transparency of water to visible light.

Ray optics: Reflection

(**Q-0418:**) Using plane mirrors alone design a setup that will allow you to see the back of your head.

(**Q-0425:**) In the following YouTube video,

https://youtu.be/GAmWs6zfTj8,

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

Ray optics: Refraction

(**Q-0430:**) In the following YouTube video,

https://youtu.be/Lic3gCS_bKo

Dr. Boyd F. Edwards demostrates total internal reflection in optical fiber. What percent of Internet communication uses optical fiber?

(**Q-0502:**) [Mirage: Inferior and superior.] Check out the following links,

Wikipedia	:	Fata Morgana (mirage),
Science World	:	Mirage (YouTube video),

on mirage. When we see a mirage light is going along a curved path. In this spirit, design a temperature gradient in air that would allow light to go in circles.