King Mongkut's University of Technology Thonburi
Midterm Exam of the 2015/2 Semester

PHY 104 General Physics for Engineering Students II
Department of Physics
Faculty of Science
Saturday 4 March, 2016 9:00 – 12:00

This Exam has 10 Pages

Instructions

1. **All Problems will be graded.**
2. **The exam can be carried out in the exam sheet or separate sheets of papers**
3. **A calculator is allowed (but not necessary at all).**
4. **Textbook and class notes are not allowed during the exam session.**

Name……………………………ID……………………..

Number	Full Score	Score
1-4	8	
5	5	
6	3	
7	6	
8	8	
9	8	
10	8	
11	8	
12	10	

1 Formulas

Electric Potential form Electrostatic Electric field

$$V_f - V_i = -\int_i^f \vec{E} \cdot d\vec{s}$$

Electrostatc Electric Filed form Electric Potential

$$E_x = -\frac{\partial V}{\partial x}$$

Capacitance

$$C = q/V$$

Force due to Electric field

$$\vec{F} = q\vec{E}$$

Electric field due to an infinite plate

$$E = \frac{\sigma}{\epsilon_0}$$

Electric field due to a point charge

$$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\hat{r}$$

Gauss's Law

$$\oint \vec{E} \cdot d\vec{a} = \frac{q_{in}}{\epsilon_0}$$

Faraday's Law

$$\oint \vec{E} \cdot d\vec{s} = -\frac{\partial \Phi_B}{\partial t}$$

Ampere's Law

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{enc}$$

Simple Harmonic Equation

$$\frac{dx^2}{dt^2} + \omega^2 x = 0$$

2 Short Problems

Exam 1 (Lecture 2). (2 points) Explain why the electric potential is the same every where inside a conductor. **Hint:** What is zero inside any conductor?

Exam 2 (Mock). (2 points) A proton of mass m is accelerated from rest by an electric field E. Calculate the speed of the proton after time t.

Exam 3 (Lecture 3). (4 points) (a) (2 points) Show that the capacitance of two infinite plates is

$$C = \frac{\epsilon_0 A}{d}$$

.

(b) (1 point each up to 3 points) Suggest methods to increase the capacitance above.

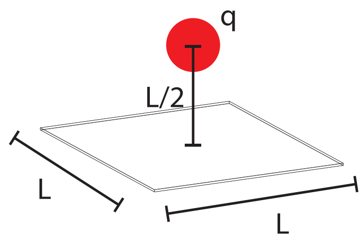
1.

2.

3.

Exam 4 (Mock)**.** (2 points) An electron of charge q and mass m is travelling from rest (at x = 0) along x-axis under potential $V = kx^{4/3}$, where k is a constant. Find the formula for the magnitude of the acceleration of the electron at distance x.

Exam 5 (HW 2)**.** (5 points) (a) (3 points) Find the electric field flux that goes through the square surface of length L due to charge q located at $L/2$ above from the center.

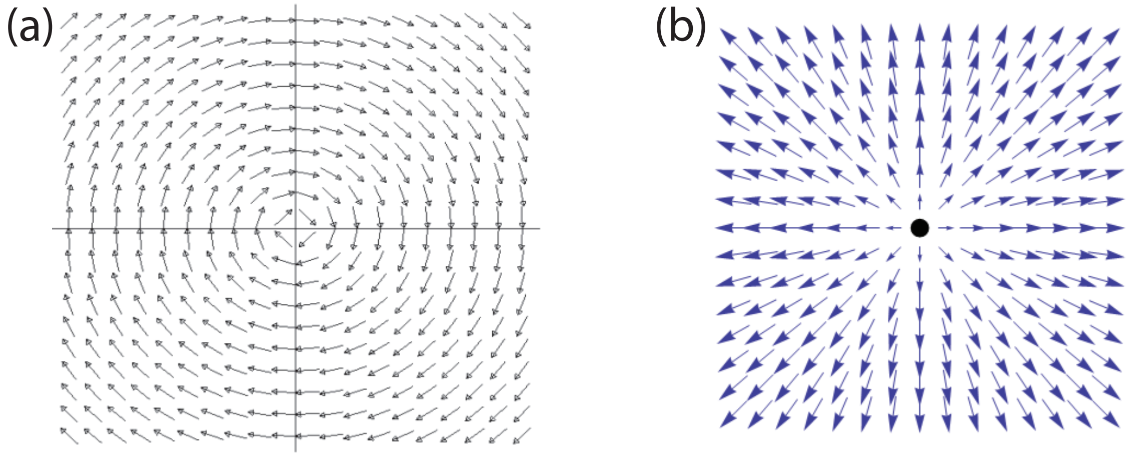


(b) (2 points) From previous problem, what is the smallest possible flux that we could have physically.

Exam 6 (Week 5)**.** (3 points) Explain how does this thing work?

Exam 7 (Week 1-5)**.** (6 points) Choose between (a) and (b) or both.
What is (are) the possible field distribution(s) of

1. Electrostatic field due to a point charge **(a, b, both)**
2. Magnetic field due to a current carrying wire **(a, b, both)**
3. Induced electric field due to the change in magnetic flux (Faraday's law) **(a, b, both)**
4. Induced magneitc field due to the change in electric flux (Maxwell-Ampere's law) **(a, b, both)**
5. Any electric field **(a, b, both)**
6. Any magnetic field **(a, b, both)**



3 Long Problems

Exam 8 (Github Week 2)**.** (8 points) Given a sphere with uniform charge density ρ and radius a: (a) (4 points) Show that the electric field as a function of distance r for the center is

$$E(r) = \begin{cases} \frac{\rho r}{3\epsilon_0} & r < a \\ \frac{\rho a^3}{3\epsilon_0 r^2} & r > a. \end{cases}$$

(b) (4 points) Find electric potential (V). Defining the potential of $V = 0$ at the infinity.

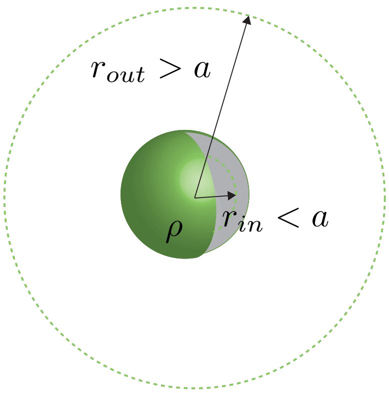


Figure 3.1

Exam 9 (Github Week 2 and Mock)**.** (8 points) (a) (4 points) Show that the electric field at point P due to a ring of uniformly distributed charge density with total positive charge Q and radius R is

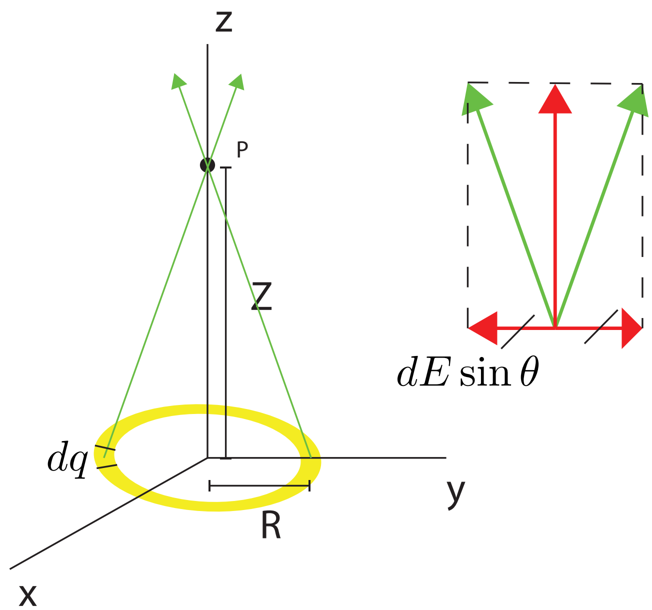


Figure 3.2

$$E = \frac{1}{4\pi\epsilon_0}\frac{Qz}{(R^2+Z^2)^{3/2}}$$

(b)(4 points) A negative charge $-q$ and mass m is placed near the plane of the ring (when Z is much smaller than R). It will undergoes a simple harmonic motion. Find the oscillation frequency.

Exam 10 (Week 3)**.** Find the capacitance of a concentric sphere. (8 points)

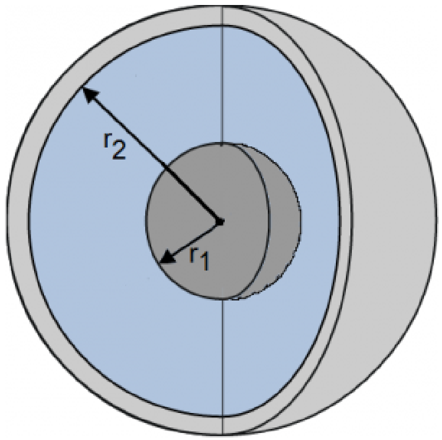


Figure 3.3

Hint: Recipe to calculate C

1. Identify the two plates
2. Put charges of $+q$ and $-q$ onto two plates (does not matter in what order)
3. Calculate E field between two plates
4. Calculate potential difference
5. Take the ratio of q and V

Exam 11 (Week 5)**.** (8 points)
A circular wire is located in an circular area containing an increasing magnetic field of $B = B_0 t$.

The induced electric field calculated from Faraday's law is

$$\oint \vec{E} \cdot d\vec{l} = -\frac{\partial \Phi_B}{\partial t} = -\frac{\partial}{\partial t} \int \vec{B} \cdot d\vec{a}$$

or

$$E_{ind} = -\frac{B_0 r}{2},$$

where the direction of the induced electric field is around the circular path.
From the definition of potential difference:

$$\Delta V = -\int_i^f \vec{E} \cdot d\vec{s}.$$

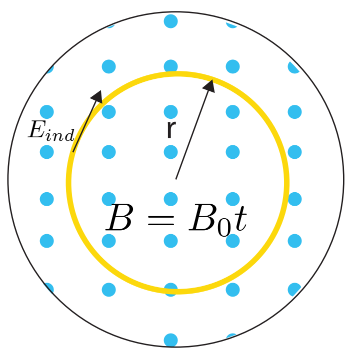


Figure 3.4

it could be seen that the potential difference of the ring is dependent of the number of rounds around the loop (N):

$$\Delta V = -\int_i^f \vec{E}_{ind} \cdot d\vec{s} = \frac{B_0 r}{r} 2\pi r N = N\pi r^2 B_0.$$

This means that we could produce any high voltage depending on the number of turns around the loop (e.g. we could produce the ΔV of 1000 Volts for a circular loop of radius r of 1 m by making 318 turns around the path for a B_0 of 1 T/s). There is no limitation of N.

Question: Can the above principle be applied to generate electricity? If not, why? What is wrong?

Exam 12 (Homework 4 Rerun)**.** (10 points) A long cylinder conductor of radius a containing a long cylindrical hole of radius b. The axes of the cylinder and hole are parallel and are distance d apart; a current I is uniformly distributed over the cross section.

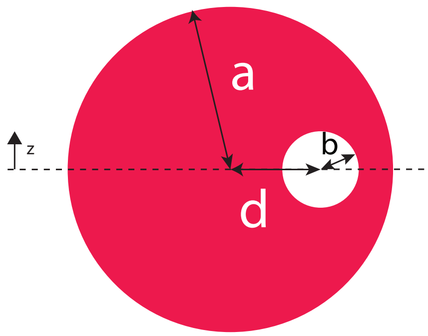


Figure 3.5

Show that (a) magnetic field at the center of the hole is

$$B = \frac{\mu_0 I d}{2\pi(a^2 - b^2)}.$$

(b) magnetic field in the hole is unform and points to the $\hat{z}$ direction everywhere in the hole i.e.

$$\vec{B} = \frac{\mu_0 I d}{2\pi(a^2 - b^2)}\hat{z}.$$