Course Code: 101180121 **Semester II AY2019/2020**

BEIJING INSTITUTE OF TECHNOLOGY

College Physics II

Make-up Exam (B)

Time allowed: 2 hours

ID:__________ Name:__________ Class No.:__________ Total Score:_____

Problem	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Marks								

INSTRUCTIONS: This examination paper contains a total of **EIGHT** problems, with a full score of 100 marks. Solve **ALL** the problems. Write your solutions clearly and neatly on the answer sheets, and nothing on the scratch paper will be counted. This is a closed-book exam, meaning that **NO** personal notes, textbooks, or any other materials shall be used during the exam. However, you may use calculators if needed.

For your reference, the following constants may be helpful.

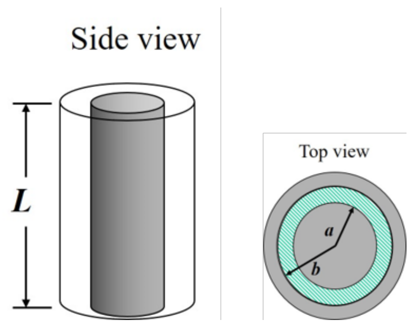
- Charge of an electron $e = -1.6 \times 10^{-19} C$
- Mass of an electron $m_e = 9.11 \times 10^{-31} kg$
- Permittivity constant $\varepsilon_0 = 8.85 \times 10^{-12} C^2/(N \cdot m^2)$
- Permeability constant $\mu_0 = 4\pi \times 10^{-7} N/A^2$
- Speed of light $c = 3 \times 10^8 m/s$
- Planck's constant $h = 6.63 \times 10^{-34} J \cdot s$

P1. (15=6+9 marks)

A long, cylindrical capacitor with a length L consists of a solid conducting wire with a radius a and a thin conducting shell with a radius b, as shown in the top view figure. The space between the inner and outer walls is filled with dielectric material with a relative permittivity ε_r. When the charge Q is stored in the capacitor, the fringing effect can be neglected.

(a) Determine the energy stored in the capacitor.

(b) The capacitor is then connected to a battery with a potential difference V, and the filling dielectric is partially pulled out of the capacitor. As the length of the dielectric pulled out of the capacitor is l, the dielectric is maintained stationary at this position of l. Find the external force required to keep the dielectric at the position of l.



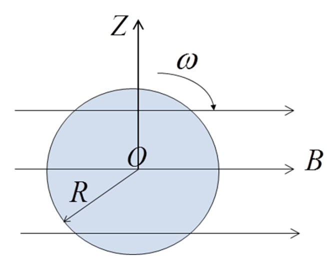
P2. (10=4+3+3 marks)

A thin, circular disc with uniform surface charge density σ and radius R is placed in a uniform magnetic field B whose direction is shown in the figure. The disc rotates around its central axis with an angular velocity ω. Find

(a) The magnetic moment of the circular disc.

(b) The torque on the disc due to the external magnetic field.

(c) The potential energy U of the disc in the field.



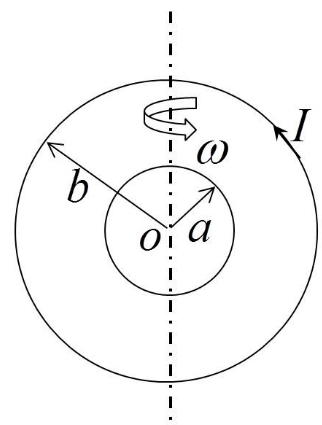
P3. (20=5+8+7 marks)

A small circular loop of radius a, and resistance R. Initially the small loop is placed in the same plane with another large loop of radius b ($b \gg a$) which is concentric with the small loop. Then fix the large loop firmly on the initial plane, and maintain a constant current I in the large loop. Subsequently, the small loop rotates around the vertical axis with a uniform angular velocity ω, as shown in the figure. (Note that the self-conductance of each loop is negligible.) Find:

(a) the current induced in the small loop.

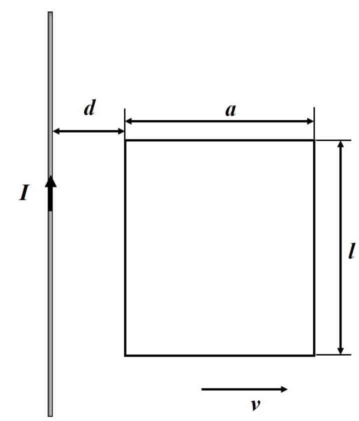
(b) to maintain the rotation of the small loop at a uniform angular velocity, what is the magnitude of torque exerted on it?

(c) the emf induced in the large loop.



P4. (10 marks)

A very long, straight wire carries a steady current I, as shown in the figure. A rectangular loop with N turns is placed coplanar with the wire and moves to the right with a constant velocity v. The length and width of the loop are l and a, respectively. Determine the EMF induced in the loop when the distance between the left border of the loop and the wire is d.

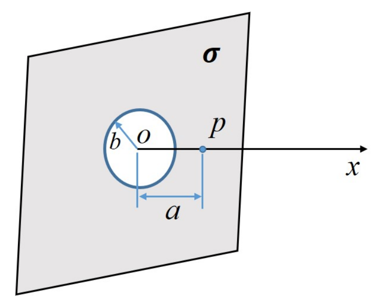


P5. (10=5+5 marks)

An infinitely large but very thin nonconducting flat plane carries a surface charge density σ. A circular aperture of radius b is then scooped out and left empty, as shown in the figure. A small particle with mass m and charge $-q$ is located at point p, which is on the central axis (x axis) of the aperture, a distance a away from the center of the aperture o.

(a) Find the electric field at point o and p, respectively.

(b) If $a \ll b$, determine the oscillatory period of the particle.



P6. (10=5+5 marks)

A 100m-long spacecraft moves at a constant speed 0.9c with respect to the ground, flying over an observation station located on the ground.

(a) How long does the spacecraft take to pass by the station if measured from the observation station?

(b) How long does the spacecraft take to pass by the station if measured from the spacecraft?

P7. (10 marks)

Harmonic oscillator is a system that, when displaced from its equilibrium position, experiences a restoring force F, proportional to the displacement x: $\vec{F} = -k\vec{x}$, where k is a positive spring constant. If F is the only force acting on the system, the system is called a simple harmonic oscillator. Estimate the minimum possible energy of a one-dimensional simple harmonic oscillator using the Heisenberg's uncertainty principle, $\Delta x \cdot \Delta p_x \geq \hbar/2$, and what is the classical prediction for the minimum possible energy?

P8. (15=6+3+6 marks)

A moving particle has the following wave function

$$\psi(x) = \begin{cases} Axe^{-\lambda x}, & x \geq 0, \\ 0, & x < 0, \end{cases}$$

where $\lambda > 0$. (Hint: $\int_0^\infty x^2 e^{-x} dx = 2$)

(a) Determine the constant A.

(b) Determine the probability density of finding the particle at a given position x.

(c) What is the most probable position of finding the particle?