For a photoelectric effect experiment, a light source of wavelength illuminates the metal surface and ejects photoelectrons:

(1) Describe the experimental setup and the main results. (10 points)

(2) Explain why the results of photoelectric effect experiment cannot be explained by the classical electromagnetic wave theory. (6 points)

(3) A light source of wavelength λ illuminates the metal surface and ejects photoelectrons whose maximum kinetic energy is found to be 1.00 eV. While using a second light source of λ /2, photoelectrons with a maximum kinetic energy of 4.00 eV are ejected. Determine the work function of this metal. (4 points)

21. A current I is running uniformly toward the positive z direction on a long thin plate lying on the x-z plane with wider width w. Find out the magnetic field at a place very close to the center part of the plate (3 points). If this plate is bent to form a cylinder centering at the z axis with radius $r = w/2\pi$, what will be the magnetic field inside and outside this cylinder (3 points)? What is the pressure acting on this cylinder due to the magnetic force induced by the parallel current (4 points)?

An electron is confined to move in the xy plane of monolayer graphene whose dimensions are L_x and L_y. That is, the electron is trapped in a two-dimensional potential well having lengths of L_x and L_y. In this situation, the allowed energies of the electron depend on two quantum number n_x and n_y. (a) Assuming $L_x = L_y = L$, construct an energy-level diagram for the electron with the lowest four energies. (16 points) (b) Determine the energy difference between the second excited state and the ground state. (4 points)

17. Which of the following statement is not true about the theory of relativity?

(A) Two events A and B occur at different locations. In some frame, event A occurs before B. There must exist another frame where event B occurs before A.

(B) Photons do not have rest mass but their trajectories can be bended by gravity.

(C) A clock in an accelerated frame ticks slower than one in an inertial frame supposing that the two clocks are identical in the same frame.

(D) The kinetic energy of a particle of rest mass m_0 and velocity v is $m_0c^2\left(\frac{1}{\sqrt{1-v^2/c^2}} - 1\right)$, where c is the speed of light in vacuum.

As described in the Bohr model, an electron is circularly orbiting a proton in a hydrogen atom, with radius $r_B = 0.5292\text{Å}$ and velocity $v = \hbar/(m_e r_B) = 2.188 \times 10^6$ m/s.

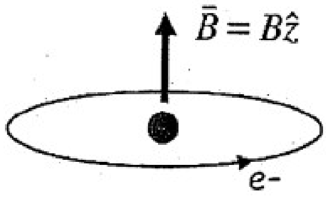
(a) (5 pts) What are the angular frequency ω and average current I associated with the electron's motion?

(b) (5 pts) What is the magnetic (dipole) moment $\vec{\mu}$ associated with this motion?

Now suppose a magnetic field $\vec{B} = B\hat{z}$ is turned on normal to the plane of this orbit. The original angular frequency ω becomes $\omega' = \omega + \Delta\omega$. The magnetic field is weak, in the sense that $eB \ll 2m\omega$.

(c) (10 pts) Suppose the orbit radius is unchanged. Find $\Delta\omega$ (in algebra, please.)

(d) (5 pts) In algebra, find the cyclotron angular frequency ω_c of a free electron in the same field.



16. Consider an electron of mass m_e confined in a one-dimensional box of size L. Supposing that it is in the ground state, what is its energy E and what is the probability p of finding it located within the region of size $L/2$ in the center of the box?

(A) $E = \frac{\hbar^2}{4mL^2}, p = \frac{1}{2} + \frac{1}{\pi}$ (B) $E = \frac{\hbar^2}{4mL^2}, p = 1 - \frac{1}{\pi}$ (C) $E = \frac{\hbar^2}{8mL^2}, p = \frac{1}{2} + \frac{1}{\pi}$ (D) $E = \frac{\hbar^2}{8mL^2}, p = 1 - \frac{1}{\pi}$.