소속대학원		수험번호		성 명		감독교수 확 인	(인)

2014학년도 석사과정/석사·박사통합과정 후기모집 면접·구술고사 전공시험

과목명 : 이론 (Theory) 2014. 5. 9 시행

[1] Let us consider 3 straight, infinitely long, equally spaced wires with mass density ρ (kg/m) in Fig. 1. The wires are separated by a distance d. Let us assume that the radius of each wire is zero. Each wire carries a current I in the same direction as in Fig. 1.

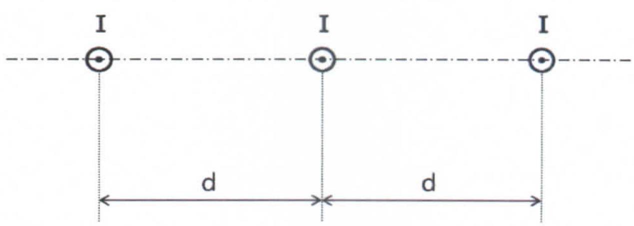

Fig. 1

(a) Obtain the location outside of the wires where the magnetic field becomes exactly zero. If there are multiple locations which satisfy the zero magnetic field condition, you must find all of them.

(b) Sketch the magnetic field line pattern.

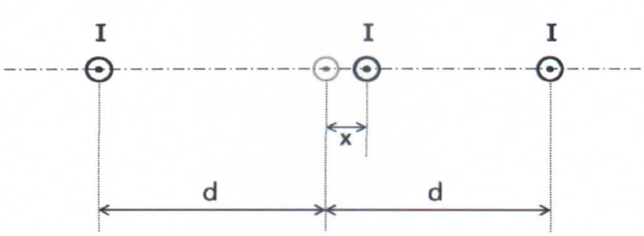

Fig. 2

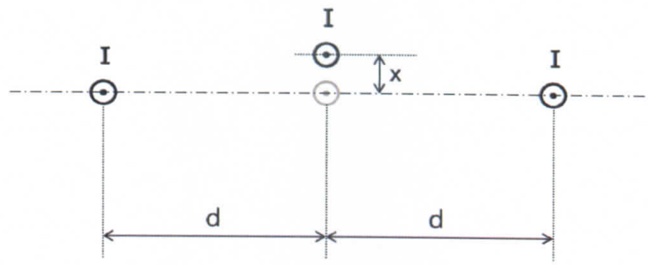

Fig. 3

(c) Let us assume that the wire in the middle is displaced by a very small distance x ($|x| \ll d$) in the same plane of the two outer wires as in Fig. 2 and as in Fig. 3, while the outer wires are held fixed. Obtain the forces per length applied to the middle wire in both cases. Using the small oscillation approximation, determine whether the motion has a stable equilibrium or not. If the motion is stable, obtain the oscillation frequency and the period of oscillation.

소속대학원		수험번호		성 명		감독교수 확 인	(인)

2014학년도 석사과정/석사박사통합과정 후기모집 면접·구술고사 전공시험

과목명 : 이론 (Theory) 2014. 5. 9 시행

[2] An electron with charge $-e < 0$ and mass m moves on the xy plane, at z=0, on which a magnetic field $B > 0$ is applied along +z direction. Its Hamiltonian is

$$\hat{H}=\frac{(\hat{p}_x+e\hat{A}_x)^2+(\hat{p}_y+e\hat{A}_y)^2}{2m}+\frac{e}{m}\vec{S}\cdot\vec{B},$$

where $\vec{S}=\frac{\hbar}{2}\vec{\sigma}$ is the spin operator. Assuming the gauge $\vec{A}=(0,Bx,0)$, $\hat{H}$ is given by

$$\hat{H}=-\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2}-\frac{\hbar^2}{2m}\left(\frac{\partial}{\partial y}+\frac{ieB}{\hbar}x\right)^2+\frac{eB}{2m}\sigma_3 \quad \ldots(A)$$

(a) As a warming-up, consider the harmonic oscillator with the Hamiltonian

$$\hat{H}=-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}+\frac{m\omega^2}{2}x^2.$$

Explain what the energy levels are. (You don't have to derive it, if you know the answer.)

(b) Consider the eigenfunctions of the Hamiltonian (A). Assuming the plane wave profile $\sim e^{iky}$ of the eigenfunction $\Psi(x,y)$ in the y direction, obtain the energy eigenvalues of $\hat{H}$. (Hint: You don't need to solve the differential equation. After assuming e^{iky} profile, $\hat{H}$ takes the form of the harmonic oscillator Hamiltonian.)

(c) Suppose that the wavefunction satisfies the periodic boundary condition in y direction, $\Psi(x,y)=\Psi(x,y+L_2)$, and the electron is confined to move in $0 < x < L_1$. Assuming that L_1 is sufficiently large, compute the ground state degeneracy N_0. If you are using any approximation for large , L_1, argue how large L_1 should be.

(d) Compute the thermal expectation values of energy and z-component of spin for this single electron system, at temperature T. Assume the same boundary conditions as problem (c).

소속대학원		수험번호		성 명		감독교수 확 인	(인)

2014학년도 석사과정/석사박사통합과정 후기모집 면접·구술고사 전공시험

과목명 : 실험 (Experiment) 2014. 5. 9 시행

[3] Consider a thin film of "material X" on a glass substrate. This film has a uniform thickness *d* which is unknown. The material X is a bit soft so that one can easily cut off a portion of the film using a razor to form a desired shape.

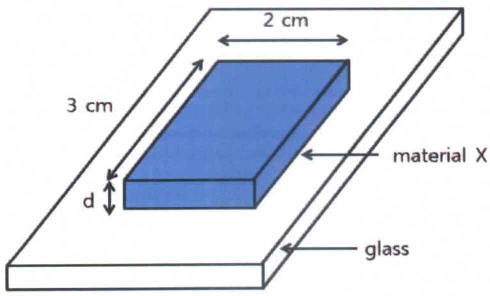

Fig. 1

(a) Please explain an experimental set-up and procedures to estimate the *resistivity* of the "material X." (You have to provide required equipments, sample preparation methods, and analysis procedures as specifically as possible.)

(b) Physics measurements cannot be perfect, and they usually have some errors coming from different origins such as equipments, sample preparation methods, data analysis methods etc. What are possible measurement errors in your measurement set-up? (You have to explain the origins and approximate size of those errors.)