소속대학원 및 학(과)부	물리천문학부 (물리학전공)	수험번호		성 명		감독교수 확 인	(인)

2018학년도 석사 및 석·박통합과정 전기모집 면접·구술고사 전공시험

과목명 : 고전역학

2017.10.20. 시행

1. (20 pts) A Rocket (mass M) is launched straight up from the earth's surface and is moving upward by gas exhaustion in order to escape from the earth. The exhausted gas has a constant velocity in the moving frame of the rocket. In this moving frame, the rocket is at rest.

(a) (6 pts) If the burn rate of the fuel is constant: $\frac{dm}{dt} = -\alpha$, find the value of the rocket's velocity at time t. We assume the rocket has only vertical motion and the acceleration of gravity is constant with height (neglect air resistance). Initial velocity is 0 at $t=0$.
[Hint: Use the Newtonian mechanics to solve this problem.]

(b) (7 pts) In the height h and latitude λ, the fuel tank of mass m_1 is separated from the rocket. This fuel tank is falling down and horizontally deflected by the Coriolis force. Find how much it is deflected from the plumb line when it arrives the surface. Use the equation $\overrightarrow{F_{eff}} = m\vec{g} - 2m\vec{w}\times\vec{v_r}$ if necessary.

(c) (7 pts) Now the rocket (its mass becomes m after losing fuel and tank) escaped from the earth and is moving in free space. It is relativistically moved in a straight line and has a velocity v with respect to the inertial frame. Exhausting gas is emitted with a constant velocity v_e with respect to the moving frame of the rocket. Show the equation of motion for the relativistic rocket is $m\frac{dv}{dt} + v_e\frac{dm}{dt}(1-\beta^2) = 0$, where $\beta = v/c$.

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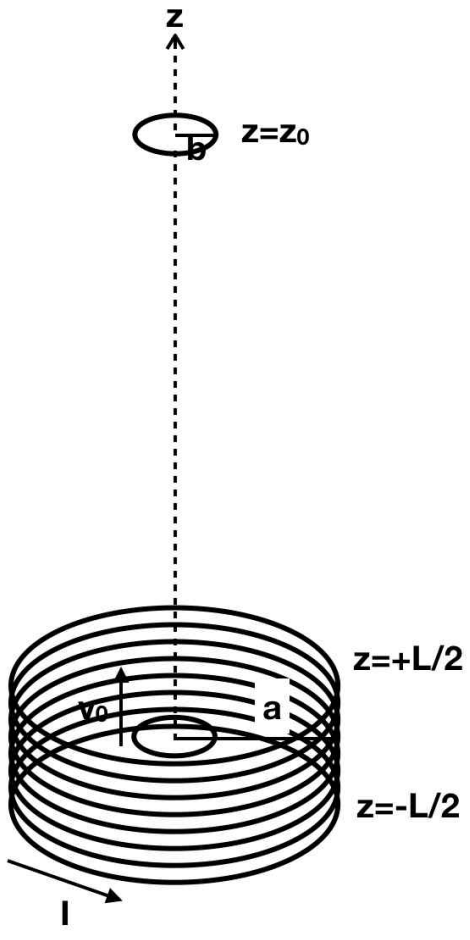
과목명 : 전자기학 **2017.10.20. 시행**

2. (20 pts) A long solenoid with length L and radius a ($a \ll L$) is placed along the z-axis centered at $z=0$ (see figure). It carries a constant current I (counter-clockwise from top view) through closely packed n ($n \gg 1$) loops per unit length.

A small circular wire of radius b ($b \ll a$) is placed on the $x-y$ plane with $z=0$ well inside the solenoid. Another small wire of the same raidus b is placed on the $x-y$ plane with $z=z_0$ outside the solenoid.



(a) (5 pts) Calculate the magnetic field at the center of the small wire at $z=0$ well inside the solenoid.

(b) (5 pts) The small wire inside the solenoid is moving upward at a velocity v_0. Calculate the induced current at this moment on the small wire which has resistance R.

(c) (10 pts) The other wire at $z=z_0$ is also moving upward with v_0. Calculate the magnetic field and the induced current on the wire.

[Hint: One can approximate the magnetic field everywhere inside the wire to be same and along the z-axis.]

- Useful integral:

$$\int \frac{dx}{(x^2+a^2)^{3/2}} = \frac{x}{a^2\sqrt{a^2+x^2}}$$

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과목명 : 양자역학 **2017.10.20. 시행**

3. (27 pts) The wavefunction of one dimensional quantum mechanical harmonic oscillator under the potential energy $V=\frac{1}{2}kx^2$ at time t=0 is given by,

$$\psi(x,0)=Ae^{-(\alpha x)^2/2}[\cos\beta H_0(\alpha x)+\frac{\sin\beta}{2\sqrt{2}}H_2(\alpha x)]$$

where β and A are real numbers, $\alpha^2=\sqrt{mk}/\hbar$ (m: mass, k : spring constant, $\hbar$: Planck's constant. Hermite polynomial H_n satisfies the following equations,

$$\int_{-\infty}^{\infty}e^{-\alpha^2x^2}[H_n(\alpha x)]^2dx=\frac{\sqrt{\pi}}{\alpha}2^n n!\ ,$$

$$H_n(-x)=(-1)^nH_n(x),$$

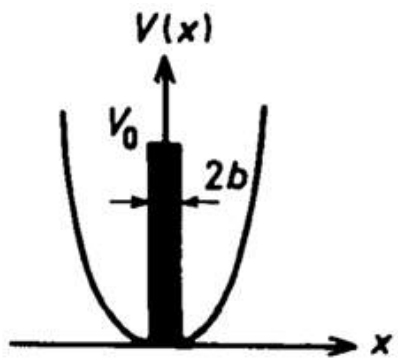
and if $n\neq m$, $e^{-\alpha^2x^2/2}H_n(\alpha x)$ and $e^{-\alpha^2x^2/2}H_m(\alpha x)$ are orthogonal.

(a) (10 pts) Write down the wave function at all times, i.e. $\psi(x,t)$.

(b) (6 pts) Calculate the position expectation value $<x>$ at t=0. (5 points) How does $<x>$ change in time ?

* Now the following additional potential energy near x=0 is added to existing harmonic potential. (see picture).

$V=V_0=constant$ for $|x|<b$



(c) (11 pts) Assuming that there is no tunneling through the barrier near x=0, and if we let $b\to 0$ (that is, the additional potential energy is like Delta function but has zero transmission probability), write down approximate Energy levels in this case (simple harmonic potential + new potential).

[Hint: (a), (b) : No need to write exact form of Hermite polynomial, (c) : No detailed calculation. Just argue logically and write down final answer.]

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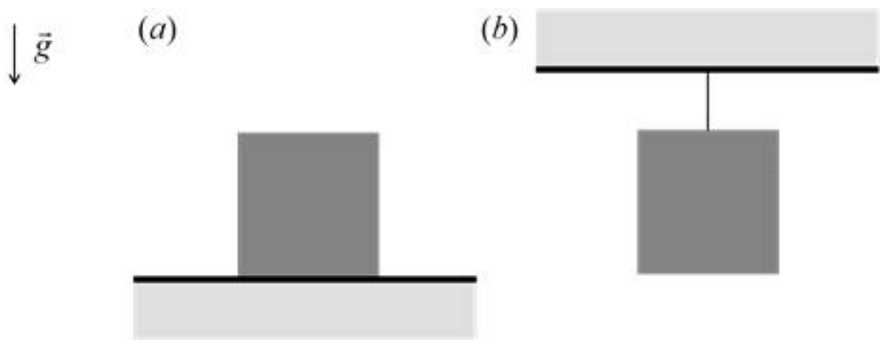
과목명 : 열 및 통계물리 **2017.10.20. 시행**

4. (13 pts) Suppose that a uniform-density cube of volume l^3 and mass m is in the room and is under pressure P and at temperature T. The gravitational acceleration is of magnitude g and its direction is downward.



Suppose that the constant-volume heat capacity is C_V and the coefficient of length thermal expansion is α.

(a) (3 pts) Show that the coefficient of volume thermal expansion is 3α. [Hint: the length of each edge of the cube under a temperature change ΔT is given by $l(1+\alpha\Delta T)$.]

(b) (6 pts) Suppose that the cube was at the bottom of the room as shown in Fig. (a) and that the cube exchanges heat with the environment so that the temperature changes by ΔT ($|\Delta T| \ll T$). What will be the change in the entropy of the cube ΔS_1?

(c) (4 pts) The change in the entropy of the cube if the cube was hanging on the ceiling by a rope as shown in Fig. (b) is ΔS_2. (Exactly as in the previous problem, the initial temperature was T and the final temperature was $T+\Delta T$.) What would be $\Delta S_2 - \Delta S_1$? Please neglect the thermal expansion of the rope. [Hint: You can solve this problem even if you have not solved (b).]

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과목명 : 실험 **2017.10.20. 시행**

5. (20 pts) Three unknown solid samples with a dimension of 1 cm × 1 cm × 1 cm are given. Only one of the samples is a single crystalline sample. Some of the samples change their physical and electrical properties drastically when they are in contact with water. (The followings are the open-end questions. Use your creativity!)

(a) (4 pts) Describe an experimental method to find out which sample is the single crystalline one.

(b) (5 pts) One wants to measure electrical properties of all three samples in the a-b plane (two of the three lattice axes a, b, c where the atomic distance in c direction is longer than the others). For this purpose, one needs to reveal a single crystalline surface of a-b plane of each sample. What would you attempt to do to prepare such a-b surfaces on all three samples? [Hint: you have a freedom to destroy or break the samples if necessary.]

(c) (5 pts) To measure the current vs. voltage (I-V) characteristics, one needs to attach wires to the sample surfaces as prepared in (b). There is a chance that the sample's overall resistance can be comparable or less than the contact resistances. Suggest a wiring configuration for a successful measurement of the I-V characteristics of the samples.

(d) (6 pts) Design an experimental set-up to measure samples' temperature dependences of I-V characteristics (from 4K to 300K). Between the two measurements at 300 K and 4 K, which one will be less noisy and why?