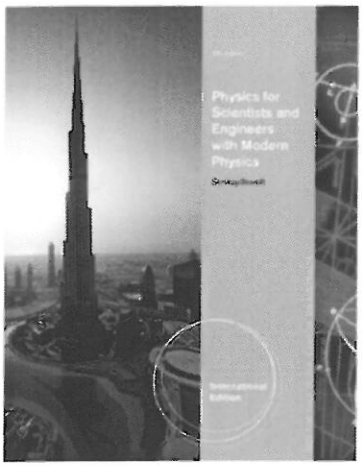
2018학년도 기초자연과학영역 학점취득특별시험 안내

III. 일반물리학2

1. 교재



Physics for Scientists and Engineers with Modern Physics (저자: Serway/Jewett)

Publisher: Brooks/Cole; International ed of 9th revised ed edition

2. 시험 범위 : 대학 일반물리학2의 2학기 강의내용으로
(교재의 33, 36, 38장을 제외한 23장 ~ 40장)

3. 출제경향 : 대학 1학년과정 2학기에 수강하는 일반물리학2는 강의가 영어로 진행되며, 중간, 기말 시험도 모두 영어로 출제됨. 본 특별시험은 기존의 기출문제와 유사하게 주관식 4문항으로 출제될 것임. 문제는 영어로 출제될 것이나, 답안작성은 영어와 국문 모두 가능하고 전자계산기는 사용 불가함.

4. 기출 문제 및 모범 답안

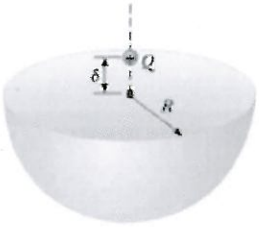
1) 2017학년도 기출문제

SUNGKYUNKWAN UNIVERSITY(SKKU)

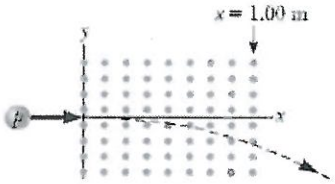
2017학년도 학점취득특별시험

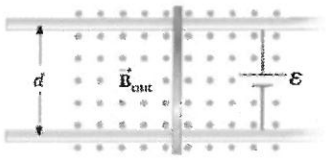
학기 Semester	2017 년	2 학기	시험구분 Exam Type	학점취득특별시험	시험시간 Exam Time	90 분/Minutes
학과/계열 Dept./Division			학번 Student PIN		성명 Name	
과목명 Subject	일반물리학2		학수번호 Course Code	GEDB010	분반 Section Number	
수업정보 Class Time	요일 Day	시간 Time	담당교수 Instructor	채경육	감독자확인 Proctor's Signature	
유의사항 Note	1. Electronic calculator is not allowed!! 2. Answer the questions in English or Korean.					

[1] [25 points] A particle with charge Q is located a small distance δ immediately above the center of the flat face of a hemisphere of radius R as shown in the figure. What is the electric flux (a) through the curved surface as $\delta \to 0$ and (b) through the flat face as $\delta \to 0$?

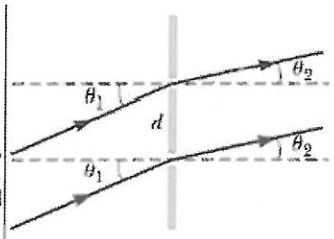


[2] [25 points] Protons having a kinetic energy of 5.00 MeV (1 eV = 1.60×10^{-19} J) are moving in the positive x direction and enter a magnetic field $\vec{B} = 0.0500\,\hat{k}$ T directed out of the plane of the page and extending from $x = 0$ to $x = 1.00$ m as shown in the figure. (a) Ignoring relativistic effects, find $\sin\alpha$ where α is the angle between the initial velocity vector of the proton beam and the velocity vector after the beam emerges from the field. (b) Calculate the y component of the protons' momenta as they leave the magnetic field. Of course you don't need to calculate the sine value in the final answer.





[3] [25 points] A bar of mass m and resistance R slides without friction in a horizontal plane, moving on parallel rails as shown in the figure. The rails are separated by a distance d. A battery that maintains a constant emf ϵ is connected between the rails, and a constant magnetic field $\vec{B}$ is perpendicularly out of the page. Assuming the bar starts from rest at time $t = 0$, find the bar's speed (v) at time t.



[4] [25 points] Coherent light rays of wavelength λ strike a pair of slits separated by distance d at an angle θ_1 with respect to the normal to the plane containing the slits as shown in the figure. The rays leaving the slits make an angle θ_2 with respect to the normal, and an interference maximum is formed by those rays on a screen that is a great distance from the slits. Express θ_2 in terms of θ_1, λ, and d. You may need to introduce an integer m to express the order number.

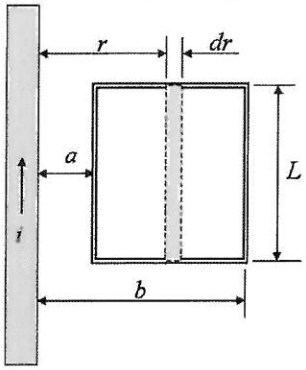
2) 2010 ~ 2016학년도 기출문제 첨부

SUNG KYUN KWAN UNIVERSITY(SKKU)

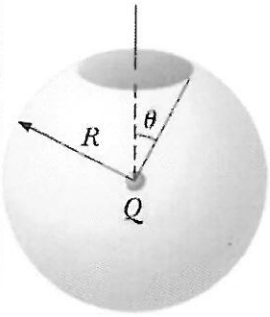
2016학년도 학점취득특별시험

학기 Semester	2016 년	2 학기	시험구분 Exam Type	학점취득특별시험	시험시간 Exam Time	90 분/Minutes
학과/계열 Dept./Division			학번 Student PIN		성명 Name	
과목명 Subject	일반물리학2		학수번호 Course Code	GEDB010	분반 Section Number	
수업정보 Class Time	요일 Day	시간 Time	담당교수 Instructor	채경육	감독자확인 Proctor's Signature	
유의사항 Note	1. Electronic calculator is not allowed!! 2. Answer the questions in English or Korean.					

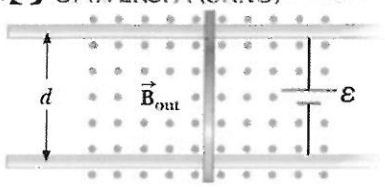
[1] [25 points] The current in the long, straight wire is upward and increasing steadily at a rate di/dt.



(a) At an instant when the current is i, find the magnitude of the magnetic field $B(r)$ at a distance r in terms of i and r.
(b) What is the total magnetic flux (Φ_B) through the loop when the current is i?
(c) What is the induced emf (ϵ) in the loop when the current is i?



[2] [25 points] A sphere of radius R surrounds a particle with charge Q located at its center as shown in the figure. Find the electric flux through a circular cap of half-angle θ.



[3] [25 points] A bar of mass m and resistance R slides without friction in a horizontal plane, moving on parallel rails as shown in the figure. The rails are separated by a distance d. A battery that maintains a constant emf ϵ is connected between the rails, and a constant magnetic field $\vec{B}$ is perpendicularly out of the page. Assuming the bar stars from rest at time $t = 0$, find the bar's speed (v) at time t.

[4] [25 points] A spacecraft with a proper length of L_p passes by an observer on the Earth. According to this observer, it takes a time interval Δt for the spacecraft to pass a fixed point. Determine the speed of the object as measured by the Earth-based observer.

SUNG KYUN KWAN UNIVERSITY(SKKU)

2015학년도 학점취득특별시험

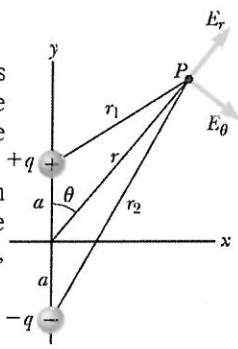
성 적

과목명	일반물리학2	학위 과정	학사	담당교수명	황정식

학부(대) 전공(학과) 학년 학번	성 명		검 인	

1. 전자계산기 사용 불가
2. 답안은 한글 또는 영문으로 작성

1. **[25 points]** An electronic dipole is located along the y axis as shown in the Figure. The magnitude of its electric dipole moment is defined as $p = 2aq$.

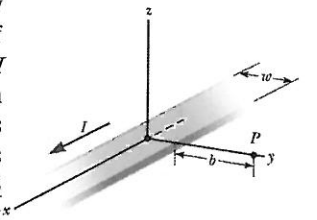


(a) (10 pts) At point P, which is far from the dipole ($r \gg a$), calculate the dipole electric potential as a function of p, r, and θ.

(b) (10 pts) Calculate the radial component E_r and the angular component E_θ of the associated electric field. (Note that $E_r = -\partial V/\partial r$ and $E_\theta = -(1/r)(\partial V/\partial\theta)$)

(b) (5 pts) Check the resulting electric fields at θ = 90° and 0°.

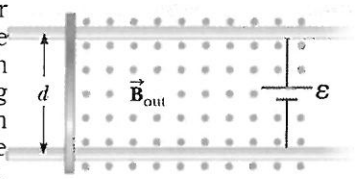
2. **[25 points]** An infinitely long thin strip of metal of width w carries a current I along its length as shown in the Figure. The current is distributed uniformly across the width of the strip. (a) (15 pts) Find the magnetic field at point P. Point P is in the plane of the strip at distance b away from its edge.



(b) (10 pts) If a charged particle passes through the point P with velocity $v_0\hat{i}$ and charge $+q$ what is the magnetic force on the particle at that moment?

(Continue on the other side of the paper)

3. [25 points] A metallic bar of mass m and resistance R slides without friction in a horizontal plane, moving on parallel rails as shown in the Figure. The rails are separated by a distance d.



A battery that maintains a constant emf ε is connected between the rails, and a constant magnetic field $\vec{B}$ is directed perpendicularly out of the page.

(a) (15 pts) Assuming the bar starts from rest at time $t = 0$, find the speed of bar at time $t(> 0)$ as a function of m, R, d, ε, B, and t.

(b) (10 pts) What is the acceleration at t and the distance travelled between $t = 0$ and $t(> 0)$.

4. [25 points]

(a) (15 pts) A particle of mass m is confined to a one-dimensional box between $x = 0$ and $x = L$.

Prove that quantized energy levels of the particle is $E_n = \left(\frac{h^2}{8mL^2}\right)n^2$, $n = 1,2,3,....$ where h is the Planck's constant. Use three hints:

1. The wave function for the particle $\psi(x) = A\sin\left(\frac{2\pi x}{\lambda}\right)$ where A is a constant and λ is the wavelength (or the de Broglie wavelength; $\lambda = \frac{h}{p}$).
2. The boundary conditions: the wave function vanishes at $x = 0$ and $x = L$.
3. The energy of the particle is the kinetic energy alone, *i.e.* $E = \frac{p^2}{2m}$.

(b) (10 pts) The period of a pendulum is measured to be 5.00 s in the reference frame of the pendulum. What is the period of the pendulum measured by an observer moving at a constant speed of $0.995c$ relative to the reference frame of the pendulum? (Use $0.995^2 \simeq 0.99$.)

SUNG KYUN KWAN UNIVERSITY(SKKU)

2014학년도 학점취득특별시험

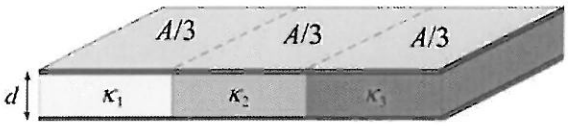
성 적

과목명	일반물리학2	학위과정	학사	담당교수명	강대준

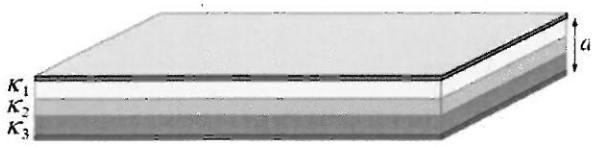
학부(대) 전공(학과) 학년 학번	성명		검인	

1. 전자계산기 사용 불가
2. 답안은 한글 또는 영문으로 작성

1. [25pts] (a) (13 points) A parallel-plate capacitor of area A and spacing d is filled with three dielectrics as shown in the figure below. Each occupies 1/3 of the volume. What is the capacitance of this system? [*Hint:* Consider an equivalent system to be three parallel capacitors, and justify this assumption.] Show that you obtain the proper limits as the dielectric constants approach unity, $\kappa_i \to 1$.]



(b) (12 points) Suppose the capacitor is filled as shown in the figure below. What is its capacitance? Use Gauss's law to find the field in each dielectric, and then calculate ΔV across the entire capacitor. Again, check your answer as the dielectric constants approach unity, $\kappa_i \to 1$. Could you have assumed that this system is equivalent to three capacitors in series?



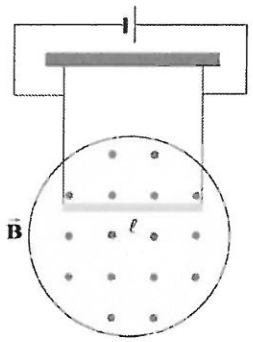
2. [25pts] A parallel plate capacitor has capacitance C. It is connected to a battery of EMF ε until fully charged, and then disconnected. The plates are then pulled apart an extra distance d, during which the measured potential difference between them changed by a factor of 4.
Below are a series of questions about how other quantities changed. Although they are related, you do not need to rely on the answers to early questions in order to correctly answer the later ones.
a) (7 points) By what factor did the energy stored in the electric field change? Make sure that you indicate whether the energy increased or decreased.

b) (10 points) A dielectric of dielectric constant κ is now inserted to completely fill the volume between the plates. Now by what factor does the energy stored in the electric field change? Does it increase or decrease?

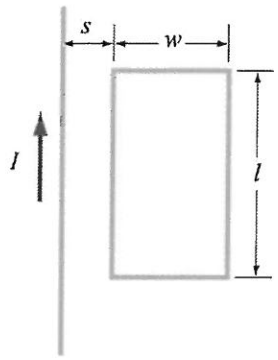
c) (8 points) What is the volume of the dielectric necessary to fill the region between the plates? (Make sure that you give your answer only in terms of variables defined in the statement of this problem, fundamental constants and numbers.

(다음 장에 계속)

3. [25pts] A conducting rod having a mass density λ kg/m is suspended by two flexible wires in a uniform magnetic field which points out of the page, as shown in the Figure below. If the tension on the wires is zero, (a) (20 points) what are the magnitude and (b) (5 points) the direction of the current in the rod?



4. [25pts] An infinite straight wire carries a current I is placed to the left of a rectangular loop of wire with width and length l, as shown in the Figure below.



(a) (12 points) Determine the magnetic flux through the rectangular loop due to the current I.

(b) (13 points) Suppose that the current is a function of time with $I(t) = a + bt$, where a and b are positive constants. What is the induced emf in the loop and the direction of the induced current?

SUNGKYUNKWAN UNIVERSITY(SKKU)

SKKU-CS-009

2013학년도 2학기 학점취득특별시험

성 적

과목명	일반물리학2	학위 과정	학사	담당교수명	강대준

학부(대) 전공(학과) 학년 학번	성 명		검 인	

1. 전자계산기 사용 불가
2. 답안은 한글 또는 영문으로 작성

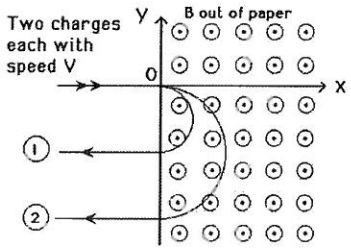
1. [25pts] Consider a system of capacitors where two parallel plate air capacitors each of capacitance C are connected in series to a battery of EMF ℰ. Now one of the capacitors is filled uniformly with a dielectric of dielectric constant K.

(a) What would happen to electric field strength of that capacitor? [10 pts]

(b) What would be the change in electric field strength? [8 pts]

(c) Calculate the amount of charge that flows through the battery? [7 pts]

2. [25pts] The entire $x-y$ plane to the right of the origin O is filled with a uniform magnetic field of magnitude B pointing out of the page, as shown. Two charged particles travel along the negative x axis in the positive x direction, each with velocity $\vec{v}$, and enter the magnetic field at the origin O. The two particles have the same mass m, but have different charges, q_1 and q_2. When in the magnetic field, their trajectories both curve in the same direction (see sketch), but describe semi-circles with different radii. The radius of the semi-circle traced out by particle 2 is exactly twice as big as the radius of the semi-circle traced out by particle 1.



(a) Are the charges of these particles positive or negative? Explain your reasoning. [10 pts]

(b) What is the ratio $\frac{q_2}{q_1}$? [15 pts]

(다음 장에 계속)

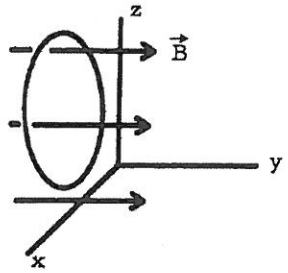
3. [25pts] A plane circular wire loop in Figure of radius = 0.010 m and resistance = 10.00Ω lies in the plane y = 0 in a spatially uniform magnetic field $\vec{B} = 0.100\cos(2\pi t/8)\,\hat{j}$.

(a) Write Faraday's law and define all terms with correct units. [7 pts]

(b) Calculate the magnetic flux through the loop at t = 1/6 s. [8 pts]

(c) Use Faraday's law to determine the induced current in the loop. [5 pts]

(d) Use Lenz's law to determine the direction of the induced current in the loop at t = 1/6 s and explain your reason. [5 pts]



4. [25pts] A monochromatic light with a wavelength of λ = 600 nm passes through a single slit which has a width of 0.800 mm.

(a) What is the distance between the slit and the screen be located if the first minimum in the diffraction pattern is at a distance 1.00 mm from the center of the screen? [15 pts]

(b) Calculate the width of the central maximum. [10 pts]

SUNG KYUN KWAN UNIVERSITY(SKKU)

SKKU-CS-009

2012학년도 2학기 학점취득특별시험

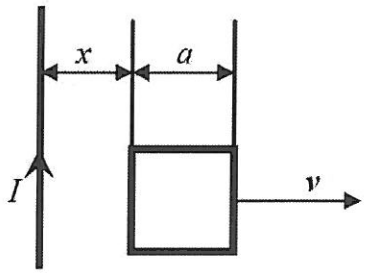
성 적

과목명	일반물리학2	학위 과정	학사	담당교수명	강대준

학부(대) 전공(학과) 학년 학번	성 명		검 인	

1. 전자계산기 사용 불가
2. 답안은 한글 또는 영문으로 작성

1. [25pts] A square conductive loop and a very long straight wire carrying electric current I are placed on a smooth horizontal non−magnetic and dielectric surface as shown in figure from the top view. The loop is pulled to the right at a constant velocity v, perpendicular to the wire.



(a) Find the electromotive force in the loop as a function of distance x and explain the origin of *emf*.

(b) Identify the direction of current in the loop.

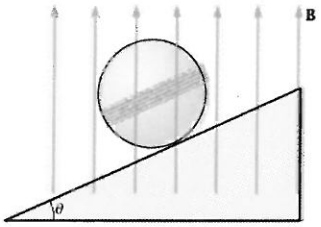
2. [25pts] Calculate the electric field due to two infinite nonconducting oppositely charged sheets brought together to a distance a.

(a) if the magnitude of the positive charge density σ_+ is twice larger than the negative charge density σ_- (i.e., $\sigma_+ = -2\sigma_-$).

(b) if the magnitudes of charge densities are the same (i.e., $\sigma_+ = -\sigma_-$)

(다음 장에 계속)

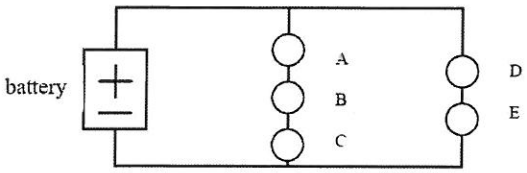
3. [25pts] A nonconducting sphere has mass 80.0 g and radius 20.0 cm. A flat compact coil of wire with 5 turns is wrapped tightly around it, with each turn concentric with the sphere. The sphere is placed on an inclined plane that slopes downward to the left, making an angle θ with the horizontal, so that the coil is parallel to the inclined plane. A uniform magnetic field of 0.350 T vertically upward exists in the region of the sphere.



(a) What current in the coil will enable the sphere to rest in equilibrium on the inclined plane?

(b) Does the result depend on the value of θ?

4. [25pts] When the following circuit is connected, how bright are the bulbs A, B, C, D, and E relative to one another? The bulbs are identical. If bulb A is removed from the circuit, what happens to the brightness of B, C, D, and E? If bulb A is replaced by two new bulbs, what happens to the brightness of the remaining bulbs?



2011학년도 2학기 학점취득특별시험

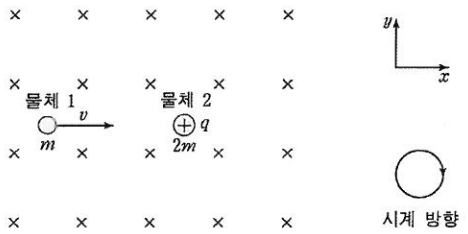
성 적

과목명	일반물리학2	학위과정	학사	담당교수명	한정훈

학부(대) 전공(학과) 학년 학번	성명		검인	

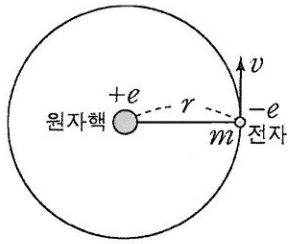
1. 전자계산기 사용 불가
2. 답안은 한글 또는 영문으로 작성

1. [25점] 그림은 균일한 자기장 속에서 $+x$방향으로 일정한 속력 v로 운동하는 물체 1이, 정지해 있는 양(+)으로 대전된 전하량 q인 물체 2와 충돌하는 모습을 나타내고 있다. 충돌 후 물체 1은 $-x$방향으로 일정한 속력 $\frac{1}{3}v$로 운동하고, 물체 2는 반지름이 r인 원 궤도를 따라 운동한다. 물체 1, 2의 질량은 각각 m, $2m$이고, 자기장의 방향은 xy평면에 수직으로 들어가는 방향이며, 자기장의 세기는 B이다.



(가) 이 문제를 해결하기 위해 요구되는 원리를 고전 역학적 측면과 전자기학적 측면에서 각각 서술하시오.
(나) 물체2의 운동 반지름 r을 구하시오 (중간 유도 과정을 빠짐없이 적으시오)
(다) 물체2의 충돌 후 속력은 시간에 따라 어떻게 변하는지 설명해 보시오.

2. [25pts] Shown on the right is Bohr's picture of an atom with one nucleus at the center and one electron orbiting it.

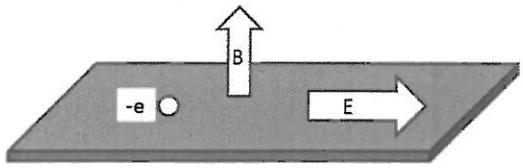


(a) In classical physics, what would be the Newtonian equation of motion of an electron? Write it down and explain.
(b) Explain why classical physics would have predicted such an atomic configuration to be unstable, i.e. decays over time.
(b) Explain how Bohr was able to understand the stability of atoms from some quantization principle.

(다음 장에 계속)

3. **[25pts]** Explain Faraday's law of induction in your own words. If possible, write down an appropriate differential equation for it. Electric field and magnetic field should be written as E(r,t) and B(r.t), respectively. Explain how the modern power generation technology depends entirely on his principle, and why having a bigger magnet inside the generator will help with greater power output.

4. **[25pts]** A thin metallic slab is subjected to an electric field in the +x direction and a magnetic field in the +z direction. Their strengths are E and B, respectively. The metallic slab has the electric conductivity equal to σ. The density of electrons in the slab is n, and electrons' charge is denoted -e.



(a) Write down the appropriate equation of motion for the electron.
(b) What is the electron's velocity in a steady state (i.e. when the total force on it becomes zero)? In such a state, how much current flows in the direction perpendicular to the E-field? Such current is called the Hall current.
(c) In a hypothetical world where the electronic charge is +e and -e, what changes will occur to the Hall current?

SUNGKYUNKWAN UNIVERSITY(SKKU)

2010학년도 2학기 학점취득특별시험

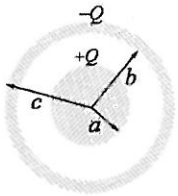
성 적

과목명	일반물리학 2	학위 과정	학사	담당교수명	

학부(대) 전공(학과) 학년 학번	성 명		검 인	

1. Electronic calculators are not allowed.
2. Answer the questions in English or Korean.
(답안은 한글로 작성가능합니다.)

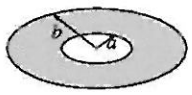
[1][25 points] A uniformly charged insulating solid sphere of radius a has a total charge $+Q$. A conducting hollow sphere whose total charge is $-Q$ has the inner radius b and the outer radius c and is concentric with the solid sphere.



(a) (15 pts) Find the magnitude of the electric field in the regions $r<a$, $a<r<b$, $b<r<c$, and $r>c$.

(b) (10 pts) Find the surface charge density σ on the inner (at $r=b$) and the outer (at $r=c$) surfaces of the hollow sphere.

[2][25 points] A disc of radius b has a circular hole of radius a as shown in the figure. The disc is put on the $x-y$ plane with the center at the origin and the surface charge density $\sigma(>0)$ is uniform.

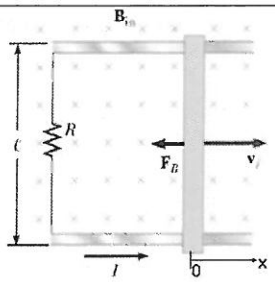


(a) (15 pts) Calculate the electric potential V at $\vec{r}=(0,0,z)$.

(b) (10 pts) Calculate the electric field at $\vec{r}=(0,0,z)$. If you put a particle of charge $-q$ and mass m on the z-axis near the origin ($z \ll a$). what kind of motion do you expect to observe? Calculate the period of the particle's motion.

(Continue on the other side of the paper)

[3][25 points] The conducting bar illustrated in the figure moves on two frictionless, parallel rails in the presence of a uniform magnetic field directed into the page. The bar has mass m, and its length is l. The bar is given an initial velocity v_i to the right ($+x$ direction) and is released at $t=0$.



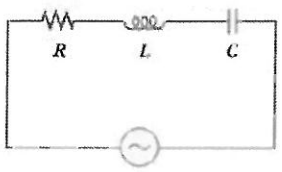
(a) (10 pts) Using Newton's laws, find the velocity of the bar as a function of time.

(b) (5 pts) Sketch a graph of the velocity of the bar as a function of time. Show that the bar will stop at $t \rightarrow \infty$.

(c) (5 pts) Find the distance the bar moves as a function of time.

(d) (5 pts) What is the maximum distance the bar moves, $x(t \rightarrow \infty)$?

[4][25 points] A series circuit consisting of a resistor, an inductor, and capacitor connected to an AC(Alternating Current) source. The RLC circuit has $R = x\,\Omega$, $L = y\,H$, $C = z\,F$, AC source with frequency $f = a\,Hz$ and the maximum output voltage of source $\Delta V_{max} = b\,V$. Here x, y, z, a, and b are positive constants.



(a) (9 pts) Determine the inductive reactance, the capacitive reactance, and impedance of the circuit.

(b) (5 pts) Find the maximum current in the circuit.

(c) (5 pts) Find the phase angle between the current and voltage.

(d) (6 pts) Find the maximum voltage across each element.

[1] (a) $\oint \vec{E}\cdot d\vec{A} = \frac{Q_{in}}{\epsilon_0}$. For $r<a$: $E\cdot 4\pi r^2 = \frac{Q}{\epsilon_0}\cdot\frac{r^3}{a^3} \Rightarrow E = \frac{Q}{4\pi\epsilon_0}\frac{r}{a^3}$

For $a<r<b$: $E\cdot 4\pi r^2 = \frac{Q}{\epsilon_0} \Rightarrow E = \frac{Q}{4\pi\epsilon_0}\cdot\frac{1}{r^2}$

For $b<r<c$: Inside conductor $\Rightarrow E=0$

For $r>c$: $Q_{in} = Q+(-Q) = 0 \Rightarrow E=0$

(b) $E=0$ for $b<r<c \Rightarrow \oint \vec{E}\cdot d\vec{A} = 0 = \frac{Q_{in}}{\epsilon_0} = \frac{1}{\epsilon_0}(Q+Q')$

$\therefore Q' = -Q$ for total charge on inner surface $\therefore \sigma = -\frac{Q}{4\pi b^2}$

For $r>c \Rightarrow E=0 \Rightarrow$ 

$\Rightarrow \sigma = 0$

(Or, total charge of hollow sphere $= -Q$
Inner surface has $-Q \Rightarrow$ outer surface $\sigma = 0$

[2] (a) Consider thin ring

$dq = 2\pi r\,dr\cdot\sigma$

$dV = \frac{1}{4\pi\epsilon_0}\cdot\frac{dq}{\sqrt{r^2+z^2}}$

$\therefore V = \int_a^b \frac{1}{4\pi\epsilon_0}\frac{2\pi r\,dr\cdot\sigma}{\sqrt{r^2+z^2}}$ $\quad r^2+z^2 = t \Rightarrow 2r\,dr = dt$

$= \int_{a^2+z^2}^{b^2+z^2} \frac{\pi\sigma}{4\pi\epsilon_0}\frac{dt}{\sqrt{t}} = \frac{\sigma}{2\epsilon_0}\left[\sqrt{b^2+z^2} - \sqrt{a^2+z^2}\right]$

(b) $\vec{E} = E_z\cdot\hat{z}$ $\quad E_z = -\frac{dV}{dz} = -\frac{\sigma}{2\epsilon_0}\left[\frac{z}{\sqrt{b^2+z^2}} - \frac{z}{\sqrt{a^2+z^2}}\right]$

Near the origin $z \ll b$, $z \ll a$

$E_z \approx -\frac{\sigma}{2\epsilon_0}\left(\frac{1}{b}-\frac{1}{a}\right)z$

$\vec{F} = m\vec{a} \Rightarrow m\frac{d^2z}{dt^2} = -\frac{\sigma}{2\epsilon_0}\left(\frac{1}{b}-\frac{1}{a}\right)z$

$\Rightarrow$ harmonic oscillation $\omega = \sqrt{\frac{\sigma}{2m\epsilon_0}\left(\frac{1}{b}-\frac{1}{a}\right)}$

$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{2m\epsilon_0}{\sigma}\frac{ab}{b-a}}$

2010학년도 2학기 학점취득 특별시험

성 적

과목명	일반물리학 2	학위과정	학사	담당교수명	

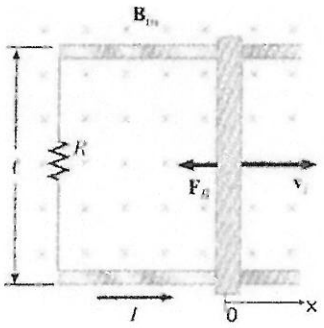
학부(대) 전공(학과) 학년 학번	성명		검인	

시험 윤리 서약서

1. 나는 대리시험을 청탁하거나 청탁받지 않겠습니다.
2. 나는 답안지에 성명을 빈형하여 기재하지 않겠습니다.
3. 나는 허용되지 않은 교과서, 노트, 기타 참고서 및 타학생의 답안지 등을 보고 답안지를 작성하지 않겠습니다.
4. 나는 타인에게 답안지를 보여주지 않겠습니다.
5. 나는 시험에 방해가 되는 행위를 하지 않겠습니다.
6. 나는 감독관의 지시와 명령에 따라 시험 과정에 참여하겠습니다.

나는 시험에 위법 행위를 하지 않고, 성균인으로서 나의 명예를 지킬 것을 약속합니다. (전자계산기 사용 금지)

[Problem 3][25 points] The Conducting bar illustrated in Figure below moves on two frictionless, parallel rails in the presence of a uniform magnetic field directed into the page. The bar has mass m, and its length is l. The bar is given an initial velocity, v_i to the right ($+x$ direction) and is released at $t=0$.



(a) [10 points] Using Newton's laws, find the velocity of the bar as a function of time.
(b) [5 points] Sketch a graph of the velocity of the bar as a function of time. Show that the bar will stop at $t\to\infty$.
(c) [5 points] Find the distance the bar moves as a function of time.
(d) [5 points] What is maximum distance, $x(t\to\infty)$?

(a) $F_x = ma = m\frac{dv}{dt} = -IlB = -\left(\frac{Blv}{R}\right)lB$ (F_B)

$\therefore \frac{dv}{dt} = -\left(\frac{(Bl)^2}{mR}\right)v$, Let $\tau \equiv \frac{mR}{(Bl)^2}$

$\int_{v_i}^{v}\frac{dv}{v} = -\int_0^t\frac{dt}{\tau} \rightarrow \ln\left(\frac{v}{v_i}\right) = -\frac{t}{\tau}$

$\therefore v(t) = v_i\exp\left(-\frac{t}{\tau}\right) = v_i\exp\left(-\frac{(Bl)^2}{mR}t\right)$

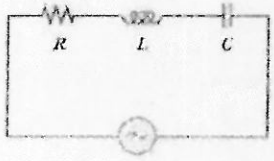
(b) v ← v_i at $t=0$; $v=0$ at $t\to\infty$; t

(c) $\frac{dx}{dt} = v \rightarrow \int_0^x dx = \int_0^t v\,dt$

$\therefore x(t) = \int_0^t v_i e^{-t/\tau}dt = v_i(-\tau)e^{-\frac{t}{\tau}}\Big|_0^t = v_i\tau\left(1-e^{-\frac{t}{\tau}}\right) = v_i\left(\frac{mR}{(Bl)^2}\right)\left(1-\exp\left(-\frac{(Bl)^2}{mR}t\right)\right)$

(d) $x(t\to\infty) = v_i\left(\frac{mR}{(Bl)^2}\right)$ ← max. distance.

[Problem 4][25 points] A series circuit consisting of a resistor, an inductor, and capacitor connected to an AC(Alternating Current) source as shown below. A series of RLC circuit has $R=x\,\Omega$, $L=y\,H$, $C=z\,F$, AC source with frequency $f=w\,Hz$ and the maximum output voltage of source $\Delta V_{max}=a\,V$. Here x, y, z, w, and a are positive constant.



(a) [9 points] Determine the inductive reactance, the capacitive reactance, and impedance of the circuit.
(b) [5 points] Find the maximum current in the circuit.
(c) [5 points] Find the phase angle between the current and voltage.
(d) [6 points] Find the maximum voltage across each element.

(a) angular freq: $\omega = 2\pi f = 2\pi(w\,Hz) = 2\pi w/s$

$X_L = \omega L = (2\pi w/s)(y\,H) = (2\pi wy)\,\Omega$

$X_C = 1/\omega C = (2\pi w/s \cdot z\,F)^{-1}$

$Z = \sqrt{R^2+(X_L-X_C)^2} = \sqrt{(x\,\Omega)^2+(2\pi wy\,\Omega - X_C)^2}$

(b) $I_{max} = \frac{\Delta V_{max}}{Z} = \left(\frac{a\,V}{Z}\right)$

(c) $\phi = \tan^{-1}\left(\frac{X_L-X_C}{R}\right) = \tan^{-1}\left(\frac{2\pi wy\,\Omega - X_C}{x\,\Omega}\right)$

(d) $\Delta V_R = I_{max}R$

$\Delta V_L = I_{max}X_L$

$\Delta V_C = I_{max}X_C$