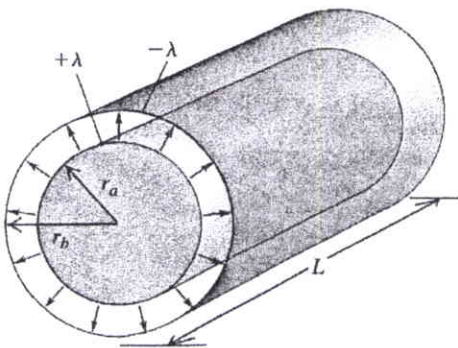


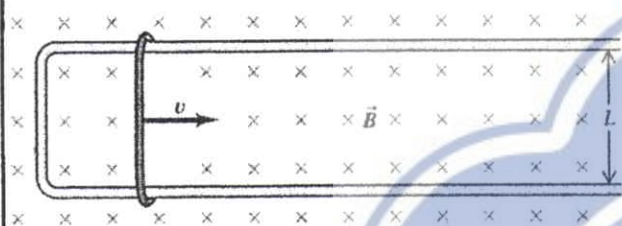
考 試 科 目	普通物理	系 所 別	應用物理研究所	考 試 時 間	2 月 4 日(四) 第 3 節
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1. A uniform rectangular wooden board of mass M is pivoted horizontally along its top edge without friction. The vertical edge of the board has length L . (a) Show that the moment of inertia of the board is $ML^2/3$. A bullet of mass m and horizontal velocity v strikes the board at the center and is embedded in the board. (b) Calculate the angular velocity of the board right after the impact and express it in terms of m , M , v and L . (c) If $M = 0.900$ kg, $m = 0.0100$ kg, and $L = 0.500$ m, what is the minimum v needed to swing the board over? (15%) ($g = 9.80$ m/s²)
2. The potential energy of a diatomic molecule is $U(r) = \frac{A}{2b}[e^{-2b(r-R_0)} - 1] - \frac{A}{b}e^{-b(r-R_0)}$, where both A and b are positive constants and r is the distance between the two atoms. (a) Find the radial force $F(r)$ on each atom. (b) What is the minimum potential energy? What is the meaning of R_0 ? (c) If x is the difference between r and R_0 and x is much smaller than R_0 , use Taylor's expansion to show that F is proportional to x and derive the force constant k in terms of A and b . (d) If each atom of the molecule has the identical mass m , what is the vibration frequency of the molecule? What is the zero-point energy of the molecule? (20%)
3. A heat engine operates between two reservoirs at $T_2 = 500$ K and $T_1 = 300$ K. It takes in 1000 J of energy from the higher-temperature reservoir and performs 250 J of work in one cycle. Find (a) the entropy change of the Universe ΔS_U for this process and (b) the work W that could have been done by an ideal Carnot engine operating between these two reservoirs. (c) Show that the difference between the amounts of work done in parts (a) and (b) is $T_1 \Delta S_U$. (15%)
4. The inner conducting cylinder of a long, cylindrical capacitor has radius r_a and linear charge density λ . It is surrounded by a coaxial cylindrical conducting shell with inner radius r_b and linear charge density $-\lambda$. (a) What is the capacitance of the system per unit length? (b) What is the total electric-field energy per unit length. (10%)



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5. A rectangular loop with width L and a slide wire of mass m are as shown in the figure. A uniform magnetic field \vec{B} is directed perpendicular to the plane of the loop into the plane of the figure. The slide wire is given an initial speed of v_0 at $t = 0$ and then released. There is no friction between the slide wire and the loop, and the resistance of the loop is negligible in comparison to the resistance R of the slide wire. (a) Obtain an expression for F , the magnitude of the force exerted on the slide wire while it is moving at speed v . (b) Find the speed $v(t)$ and displacement $x(t)$ in terms of B , L , m , R and v_0 . (c) Find the maximum distance the slide wire moves. (d) What is the total energy consumed by the resistance R ? (20%)



6. A source of sinusoidal electromagnetic waves radiates uniformly in all directions with an average power of 50.0 kW and frequency 100 MHz. At a distance 10.0 km from the source there is a circular loop of wire with diameter 0.200 m. Calculate (a) the intensity of the electromagnetic wave and (b) the amplitudes of the electric and magnetic fields at the location of the loop. (c) If the loop is perpendicular to the direction of the radiation's magnetic field, what is the maximum electromotive force induced in the wire? (20%)
($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T·m/A, $\epsilon_0 = 8.85 \times 10^{-12}$ C²/N·m².)

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註

- 一、作答於試題上者，不予計分。
- 二、試題請隨卷繳交。

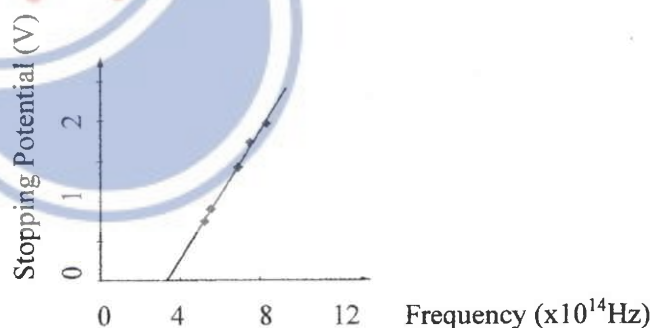
考 試 科 目	近代物理	系 所 別	應用物理所	考 試 時 間	2 月 4 日 (四) 第 四 節
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Planck' s constant: $\hbar = 1.06 \times 10^{-34} \text{Js}$, $h = 6.63 \times 10^{-34} \text{Js}$. Speed of light: $c = 3.00 \times 10^8 \text{m/s}$.
 Boltzmann constant: $k_B = 1.38 \times 10^{-23} \text{J/K}$. Charge of electron: $-e = 1.60 \times 10^{-19} \text{C}$.
 Mass of electron: $m_e = 9.11 \times 10^{-31} \text{kg}$. $1\text{J} = 6.24 \times 10^{18} \text{eV}$.

1. [40 points] Short answer questions

- 1.1 [6 points] Describe briefly the Stern-Gerlach experiment for the measurement of the magnetic moments of atoms, and discuss the significance of the results.
- 1.2 [4 points] Explain Larmor precession.
- 1.3 [5 points] Which of the following are characteristics about the quantum harmonic oscillator? Choose all that apply.
 - I. Evenly spaced energy states
 - II. The potential energy function is symmetric about the origin in the position coordinate
 - III. The ground state has zero kinetic energy
 - IV. The probability of finding the particle outside the classically allowed range is nonzero
 - V. The ground state energy is zero
- 1.4 [4 points] For a single quantum harmonic oscillator that has an angular frequency ω . At temperature T , what is the partition function?
- 1.5 [6 points] Write down the distribution function for photons and fermions, respectively.

Questions 1.6 – 1.8 refer to the photoelectric effect and the figure on the right. For an experiment observation, the stopping potential was plotted versus the light frequency, as shown in the figure. The best straight line was fitted to the experimental points.



- 1.6 [4 points] In an experimental observation of the photoelectric effect, does increasing the light amplitude change the stopping potential?
- 1.7 [5 points] What is the physical interpretation of the horizontal intercept?
- 1.8 [6 points] What is physical interpretation of the slope of the line?

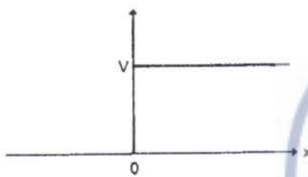
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2. [20 points] A particle in the infinite square well has the wave function, $\psi(x) = \begin{cases} A(x/a), & 0 \leq x \leq a \\ \frac{A(b-x)}{b-a}, & a \leq x \leq b \\ 0, & \text{otherwise} \end{cases}$

2.1 [10 points] Sketch ψ and determine the constant A in terms of a, b .

2.2 [10 points] What is the probability of finding the particle to the left of a ?

3. [10 points] An electron has a speed $v=0.85c$, c is the speed of light. Find its total energy and kinetic energy in electron volts.
4. [10 points] A free particle of mass m and energy E is moving from $x = -\infty$ to $x = \infty$. There is a potential step V , where $V < E$, for $x \geq 0$. Find the transmission and reflection coefficients for the particle in the one-dimensional step potential.



5. [20 points] There are N free electrons in a metal of volume V and the temperature is at absolute zero. It is also known that the distribution of the free electron energy can be described by the density of the electron energy levels $g(\epsilon) = \frac{8\pi V m^{3/2} \sqrt{2\epsilon}}{h^3}$, where ϵ is the (kinetic) energy of the free electron and $g(\epsilon)d\epsilon$ is the number of electronic energy levels (including both spins) between ϵ and $\epsilon + d\epsilon$, m the mass of electron, and h the Planck's constant.
- 5.1 [10 points] Calculate the highest energy level (called Fermi energy) ϵ_f of the electron in the metal in terms of N , V and m .
- 5.2 [10 points] What is the total energy of all the N electrons in the metal as expressed in terms of N and ϵ_f ? What is the average electron energy?

備

註

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