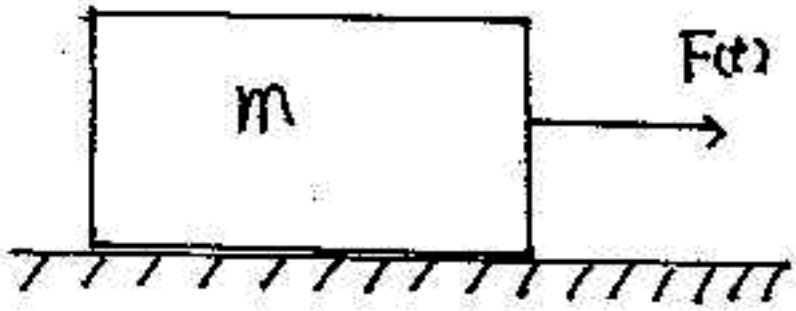
八十八學年度 物理 系(所) 原子物理 組碩士班研究生招生考試

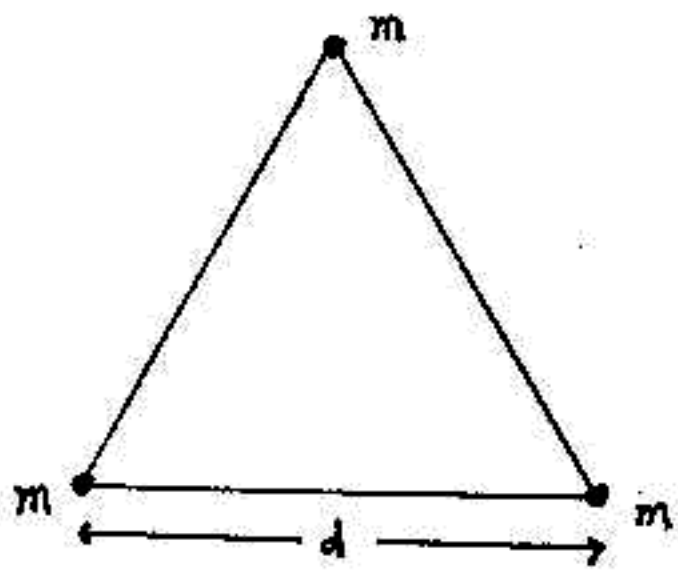
科目 普通物理 科號 0402 共 三 頁第 一 頁 *請在試卷【答案卷】內作答

Part one

Fill in the blanks of problems 1 - 10; 6% for each problem. Please mark the problem numbers clearly in the answer sheet, and provide ONLY your answers to these problems.

(1) A horizontal force $F(t) = ct$ is applied to pull the block of mass m, as shown below (left); c is a constant and t the time. The static and the kinetic friction coefficients between the block and the surface are the same and are given by μ. The block is at rest at $x = 0$ when $t = 0$. It would start to move at $t_0 =$ (1a) The position of this block at t_1 ($t_1 > t_0$) is (1b)





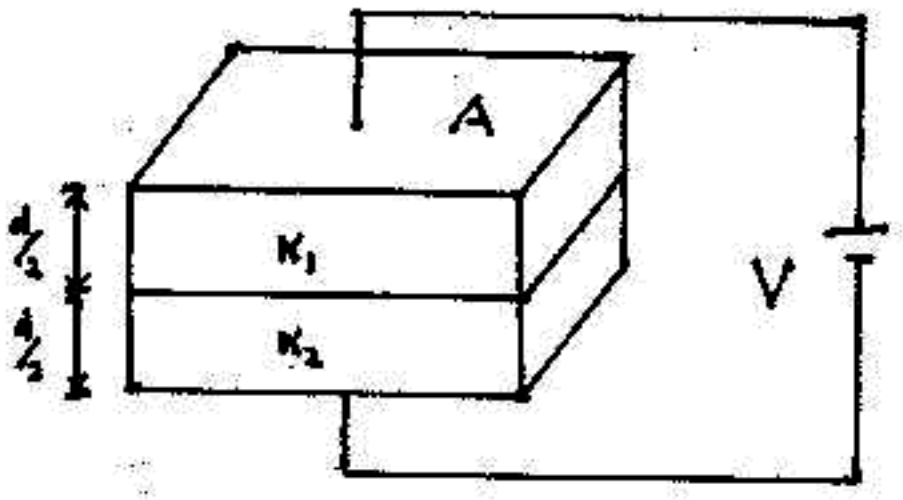
(2) Three stars all of mass m are separated by a distance d from each other (as shown above, the right figure) and rotating about their center of mass. The stars, under the gravitational force from each other, keep their separations unchanged during the rotation. The potential energy of the system is (2a) and the total angular momentum of the system is (2b)

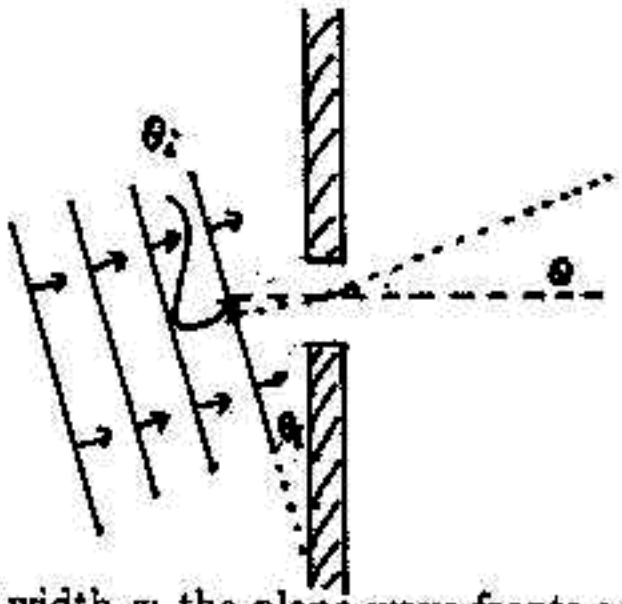
(3) There is an ideal gas of N particles undergoing a free expansion from V_1 to $V_2 = 2V_1$ at the temperature T. The ideal gas is then isothermally compressed back to V_1. The total entropy change of the ideal gas is (3a), and the total entropy change of the external world is (3b).

(4) An ideal gas of N particles is in a volume V and at temperature T. The mass of each particle is m. The root mean square speed, v_{rms} of each particle is (4a) If the gas is adiabatically expanded to $2V$, the v_{rms} would change by a factor of (4b) The ideal gas has $\gamma = c_p/c_v = 5/3$.

(5) An unpolarized light of intensity I is traveling in the $+z$ direction. The light passes through three polarizers A, B and C successively. The polarization axis of A is along the x-axis, and that of C along the y-axis. The outgoing light has the maximum intensity when the polarization axis of B has an angle (5a) about the x-axis, and this maximum intensity has the value of (5b).

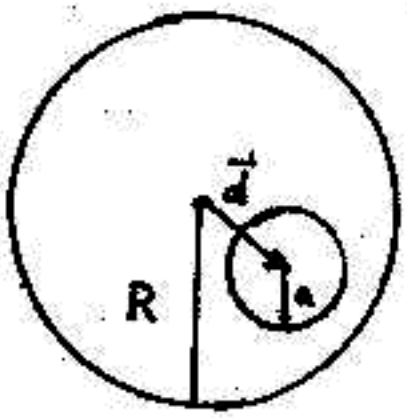
(6) A parallel-plate capacitor has a surface area A and the plate separation d. Two dielectric slabs, of constants κ_1 and κ_2, each of thickness $d/2$, are inserted between the plates as shown below (left). The capacitance of this system is (6a). If the capacitor is connected to a battery of potential difference V, the energy stored in the capacitor is (6b).

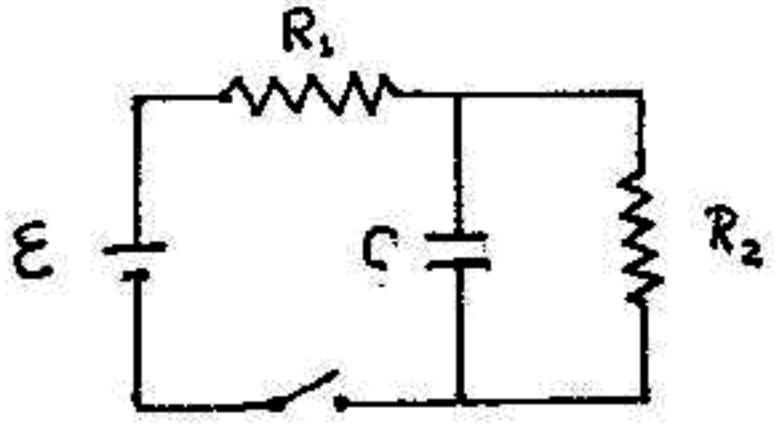




(7) Light of wavelength λ arrives at a single slit of width a; the plane wave fronts arrive at the slit at an angle θ_i (see the figure above in the right). The dark fringes on a very distant screen appear at the angles θ determined by the relation $sin\theta =$ (7).

(8) A sphere of radius R is charged uniformly with charge density ρ except for a spherical cavity of radius a as shown in the left figure below. The electric field (a vector) within the cavity is (8).



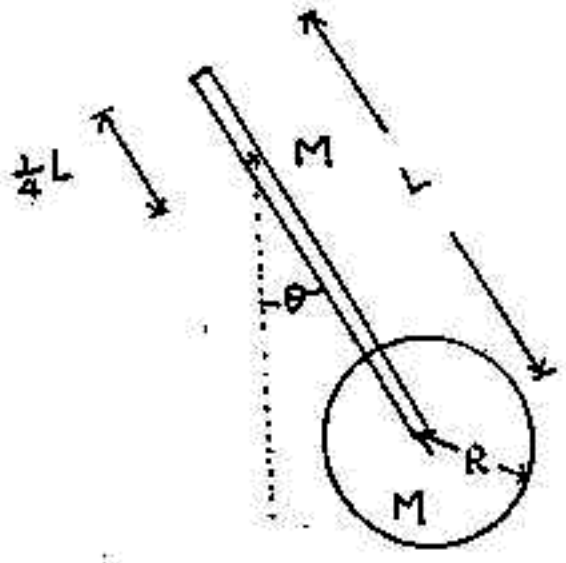


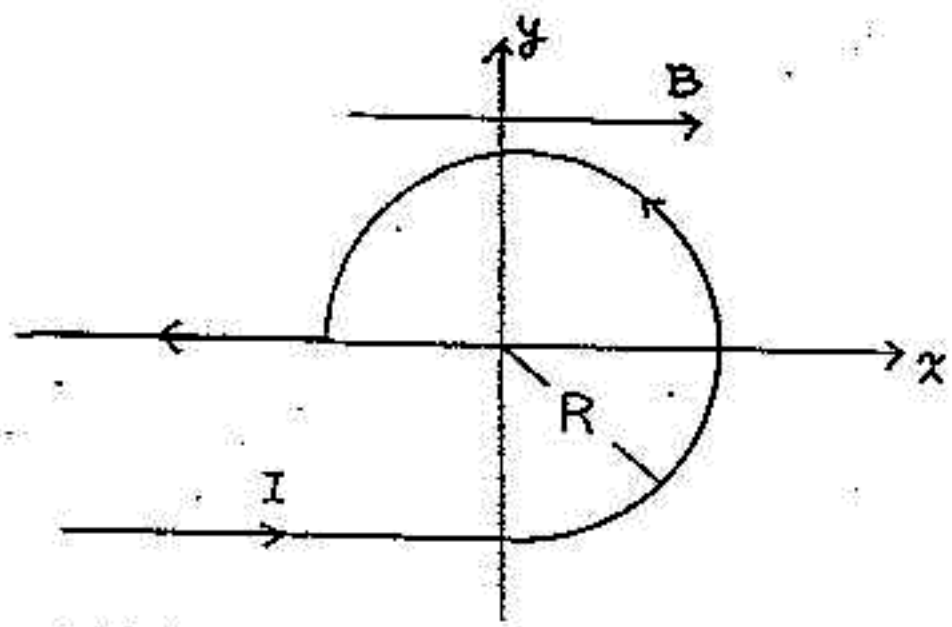
(9) The switch in the figure above (right) is closed at $t = 0$. The current through the R_1 right after the circuit is closed (i.e. at $t = 0$) is (9a). The charge stored in the capacitor is $Q(t) =$ (9b).

(10) An hydrogen atom is at its ground state. The minimun energy required to excite this atom is (10a) eV. The wavefunction of this atom has the form: $\psi(r) = Cexp(-r/a)$, where a is the Bohr radius. In terms of a the constant C can be expressed as (10b).

Part two Problems 11 -14; 10% for each problem. You are required to show details of your derivations and calculations.

(11) There is a uniform rod of length L and mass M. At one end of the rod there is a thin metal disc of radius R and also of mass M. The rod is fixed at a point $\frac{1}{4}L$ from the other end (as shown below on the left) and may swing freely, under gravity, about this point. (a) Evaluate the moment of initia about the fixed point. (b) Write down the equation of motion that determines the motion of the rod at θ, which is the angle between the rod and the vertical axis. (c) If the rod is released from rest at a small θ_o, show how the equation of motion can be simplified. Use the result to determine the motion of the rod.





(12) The circuit shown in the figure above (right) carries a current I and lies flat on the xy-plane. A constant B-field is in the x-direction. Evaluate the magnetic force on the circuit and also the torque about the y-axis.

(13) A string of constant density μ is fixed on one end ($x = 0$)at the wall. A tension T is in the string. Waves on the string are determined by the wave equation: $T\frac{\partial^2 z}{\partial x^2} = \mu\frac{\partial^2 z}{\partial t^2}$. Suppose a harmonic wave of the form $z(x,t) = z_0 sin(kx - \omega t)$ is traveling on the string. (a) Determine the speed of this wave in terms of T and μ. (b) Also evaluate the time-averaged kinetic energy density (i.e., average kinetic energy per unit length) as a function of x.

(14) The electric field of a polarized light wave is given by $\mathbf{E} = E_0\hat{\mathbf{x}}cos(ky + \omega t)$. (a) What is the Poynting vector S? Consider the light as a uniform flux of photons traveling at the speed of c. (b) What is the density of photons in this light beam? (c) If the light shines on a mirror at 45^0 and is reflected by it, what is the radiation pressure on the mirror?