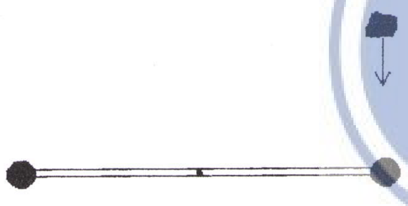
國立政治大學 102 學年度碩士班招生考試試題

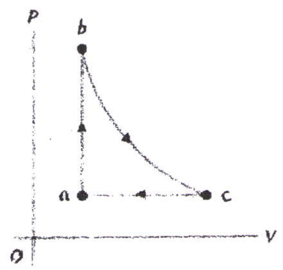
考 試 科 目	普通物理	系 別	應用物理研究所	考 試 時 間	2 月 24 日(日) 第 1 節

1. The force $F(x)$ between a fixed nucleus and an α particle of mass m is repulsive and can be expressed as $F(x) = a/x^2$, where a is a constant and x is the distance between them. (a) Calculate the potential energy $U(x)$ between the α particle and the nucleus, setting $U(x) = 0$ as $x \to \infty$. (b) If the α particle is on a head-on collision course with the fixed nucleus and when their distance is l the speed of the α particle is $(18a/ml)^{1/2}$, at what distance is the α particle nearest to the nucleus? (10%)

2. Two 2.00 kg balls are attached to the ends of a thin rod of negligible mass, 0.500 m long. The rod is free to rotate in a vertical plane without friction about a horizontal axis through its center. While the rod is horizontal, as shown in the figure below, a 0.500 kg putty wad drops onto one of the balls from a height of 0.459 m and sticks to it. (a) What is the speed of the putty wad just before the impact? (b) What is the angular speed of the system just after the impact? (c) What is the ratio of the kinetic energy of the entire system after the collision to that of the putty wad just before? (d) Through what angle will the system rotate until it momentarily stops? (e) What minimum height for the release of the putty wad would be required for the entire system to swing all the way over after impact? ($g = 9.80$ m/s^2) (20%)



3. A heat engine operates using the cycle shown below. The working substance is 2.00 mol of helium gas, which reaches a maximum temperature of 600 K. Assume the helium can be treated as an ideal gas. Process bc is isothermal. The pressure in states a and c is 1.00×10^5 Pa, and the pressure in state b is 3.00×10^5 Pa. (a) How much heat enters the gas and how much leaves the gas each cycle? (b) How much work does the engine do each cycle, and what is the efficiency? (c) Compare this engine's efficiency with the maximum possible efficiency attainable with the hot and cold reservoirs used by this cycle. (For He atoms, $C_p = 5R/2$, $C_V = 3R/2$, $R = 8.314$ J/mol·K) (20%)



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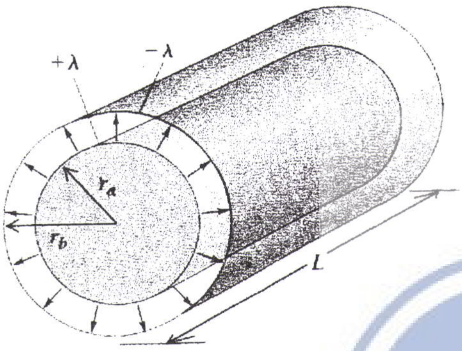
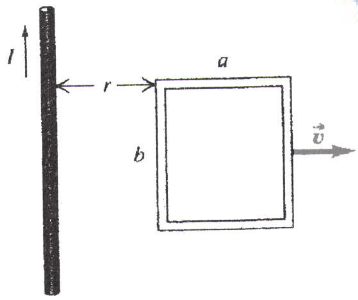
4. The inner conducting cylinder of a long, cylindrical capacitor has radius r_a and linear charge density λ. It is surrounded by a coaxial cylindrical conducting shell with inner radius r_b and linear charge density $-\lambda$. (a) What is the potential difference between the inner cylinder and outer shell? (b) What is the capacitance of the system per unit length? (c) What is the energy density in the region between the inner and outer conductors at a distance r from the axis? (d) Integrate the energy density calculated in part (c) over the volume between the conductors in a length L of the capacitor to obtain the total electric-field energy per unit length. (20%)



5. In figure below the loop is being pulled to the right at constant speed v. A constant current I flows in the long wire, in the direction shown. Calculate the magnitude of the net electromotive force (emf) induced in the loop and specify the direction (clockwise or counter clockwise) of the current induced in the loop. (10%)



6. An L-C circuit consists of a 60.0-mH inductor and a 250-μF capacitor. The initial charge on the capacitor is 6.00 μC, and the initial current in the inductor is zero. (a) What is the maximum voltage across the capacitor? (b) What is the maximum current in the inductor? (c) What is the maximum energy stored in the inductor? (d) When the current in the inductor has half its maximum value, what is the charge on the capacitor and what is the energy stored in the inductor? (e) What is the frequency of oscillation of the circuit? (20%)

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