1. (15 pts) Suppose that a hole were drilled to the center of the Earth and an evacuated pipe were inserted in the hole. Assume the radius of the Earth is R and the density is uniform with the total mass M. An object of mass m is dropped down the pipe. (Fig. 1) Find the velocity of the object when it reaches the center, and the time it takes for the object to reach the center.

2. (10 pts) A thin uniform rod of mass M and length L is positioned vertically above an anchored frictionless pivot point (Fig. 2), and then allowed to fall to the ground. With what speed does the free end of the rod strike the ground?

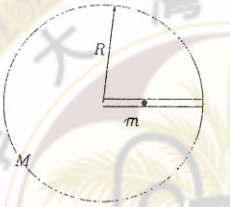

Fig. 1

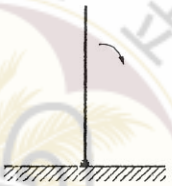
Fig. 2

3. (10 pts) A mass of m_1 at temperature T_H is placed in thermal contact with another mass of m_2 at temperature T_C. The entire system is isolated so that heat transfer occurs only between the two masses. The final equilibrium temperature is T, where $T_C < T < T_H$, and the specific heats of the masses are c_1 and c_2 respectively. Find the total entropy change associated with the heat transfer between the hot and cold masses.

4. (15 pts) An ideal monatomic gas expands quasi-statically to twice its volume. If the process is isothermal, the work done by the gas is W_i. If the process is adiabatic, the work done by the gas is W_a. Show that $0 < W_a < W_i$.

5. (12 pts) A dielectric slab of thickness b = 2.0 mm and dielectric constant κ = 2.5 is thrust into a parallel-plate capacitor of plate area A = 3.2 cm^2 and plate separation d = 5.0 mm, as shown in Figure 5; the slab is exactly halfway between the plates.
(a) What is the capacitance after the dielectric slab is introduced?
(b) If a charge q = 3.40 μC is maintained on the plates, what is the ratio of the stored energy before to that after the slab is inserted? [Hint: $\varepsilon_0 = 8.85\times10^{-12}$ F/m = 8.85×10^{-12} C^2/N·m^2].

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6. (14 pts) Figure 6 shows a cross section of a long thin ribbon of width W that is carrying a uniformly distributed total current i into the page.

(a) What are the magnitude and direction of the magnetic field at point P, at a distance D from the ribbon along its perpendicular bisector (lies on the y axis)?

(b) At point P, a charge q is distributed uniformly around a small thin ring of radius r ($r << D$, *and* $r << W$). The ring is rotating about the y axis through its center at P and perpendicular to its plane, at an angular speed ω. What is the magnitude of the torque on the small ring due to the ribbon? [Hint: $\int \frac{dx}{(x^2+a^2)^{3/2}} = \frac{x}{a^2(x^2+a^2)^{1/2}}$]

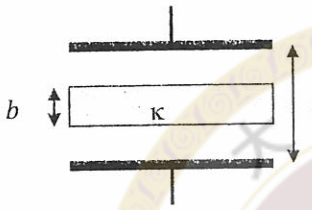

Fig. 5

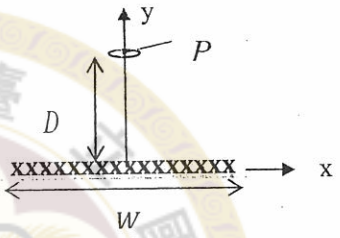

Fig. 6

7. (12 pts) A disabled tanker leaks kerosene (煤油, n = 1.20) into the ocean, creating a large slick (浮油) on top of the water (n = 1.30).

(a) If you are looking straight down from an airplane, while the Sun is overhead, at a region of the slick where its thickness is 500 nm, for which wavelength of visible light (λ = 430 ~ 690 nm) is the reflection brightest because of constructive interference?

(b) If you are scuba diving (潛水) directly under this same region of the slick, for which wavelength of visible light is the transmitted intensity strongest?

8. (12 pts)

(a) A 100 W sodium lamp (λ = 589 nm) radiates energy uniformly in all directions. What is the photon flux (photons per unit area per unit time) on a small screen 1.0 m from the lamp?

(b) If the work function for a certain metal is 1.8 eV, what is the stopping potential for electrons ejected from the metal when the sodium-lamp light shines on the metal via this small screen of area = 5.0×10^{-4} m^2 ? [Hint: the Plank constant $h = 6.626 \times 10^{-34}$ J·s, and the speed of light $c = 3.0 \times 10^{8}$ m/s.]

試題隨卷繳回