考試科目	普通物理學	所別	應用物理研究所 8162, 8163	考試時間	2月25日(六) 第三節

[*Please note that there are 6 questions on two pages. Answers in both Chinese and English are acceptable.*]

1. [24 points] Short answer questions

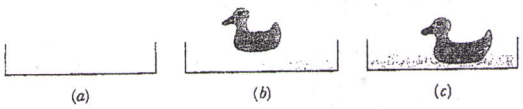

Fig. 1

(1) [4] Figure 1 shows three identical open-top containers filled to the brim with water; toy ducks float in two of them. Rank the containers and contents according to their weight, greatest first.

(2) [4] Pipe A has length L and one open end. Pipe B has length $2L$ and two open ends. Which harmonics of pipe B have a frequency that matches a resonant frequency of pipe A?

(3) [4] Three Carnot engines operate between temperature limits of (a) 400 and 500 K, (b) 500 and 600 K, and (c) 400 and 600 K. Each engine extracts the same amount of energy per cycle from the high-temperature reservoir. Rank the magnitudes of the work done by the engines per cycle, greatest first.

(4) [4] Three wires, of the same diameter, are connected in turn between two points maintained at a constant potential difference. Their resistivities and lengths are ρ and L (wire A), 1.2ρ and $1.2L$ (wire B), and 0.9ρ and L (wire C). Rank the wires according to the rate at which energy is transferred to thermal energy within them, greatest first.

(5) [4] If the magnetic field of a light wave oscillates parallel to a y axis and is given by $B_y = B_m \sin(kz - \omega t)$, (a) in what direction does the wave travel and (b) parallel to which axis does the associated electric field oscillate?

(6) [4] Figure 2 shows four choices for the rectangular opening of a source of either sound waves or light waves. The sides have lengths of either L or $2L$, with L being 3.0 times the wavelength of the waves. Rank the openings according to the extent of (a) left-right spreading and (b) up-down spreading of the waves due to diffraction, greatest first.

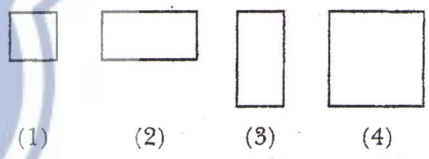

Fig. 2

2. [14 points] Consider a round uniform body of mass M and radius R rolling (without slipping) smoothly down a slope at angle θ to the horizontal level.

(a) Find an expression for the acceleration a_{COM} of the center of mass of the body down the slope (in terms of M, θ, R, free-fall acceleration g and the rotational inertia I_{COM} about the horizontal axis through the body's center of mass).

(b) What is the expression if the body is a solid sphere and if it is a solid cylinder?

(*continued on next page*)

備註	試題隨卷繳交

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3. [15 points] A block with mass m_1 attached to a horizontal spring with force constant k is moving in simple harmonic motion with amplitude x_m. At the instant when the block passes through its equilibrium position, a lump of putty of mass m_2 is dropped vertically onto it from a very small height and sticks to it.

(a) Find the new period and amplitude.

(b) Was there a loss of mechanical energy? If so, calculate the ratio of the final to the initial mechanical energy.

(c) What are the answers to part (a) if the putty is dropped on the block when it is at one end of its path?

4. [15 points] Five moles of an ideal gas undergo a reversible isothermal expansion from volume V_1 to volume $V_2 = 2V_1$ at temperature $T = 400$ K. (The gas constant R is 8.3 J/mol • K.)

(a) Find the work done by the gas.

(b) Find the entropy change of the gas.

(c) If the expansion is reversible and adiabatic instead of isothermal, what is the entropy change of the gas?

5. [16 points] A nonconducting solid sphere has a uniform volume charge density ρ. Let $\vec{r}$ be the vector from the center of the sphere to a general point P within the sphere.

(a) Calculate the electric field at P.

(b) A spherical cavity is hollowed out of the sphere, as shown in Fig. 3 where $\vec{a}$ is the position vector from the center of the sphere to the center of the cavity. Calculate the electric field within the cavity.

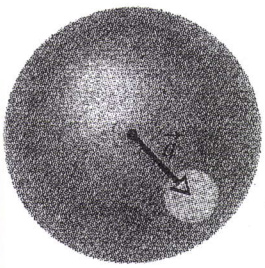

Fig. 3

6. [16 points] Figure 4 shows a rod of length L that is forced to move at constant speed v along horizontal rails. The rod, rails, and connecting strip at the right form a conducting loop. The rod has resistance R; the rest of the loop has negligible resistance. A current i through the long straight wire at distance a from the loop sets up a (*nonuniform*) magnetic field through the loop.

(a) Find the emf ε (in terms of i, v, a, L, and permeability constant μ_0).

(b) What is the current i_l in the conducting loop? At what rate P_t is the thermal energy generated in the rod?

(c) What is the magnitude F and direction of the force that must be applied to the rod to make it move at constant speed?

(d) At what rate P_f does this force do work on the rod?

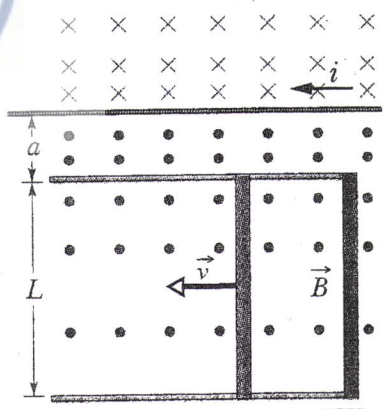

Fig. 4

(*end*)

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