10%(1): Consider A cart of mass M, shown in the Fig.1, a string attaches to the cart, and hang over the pulleys on a fixed wall, then return to the cart, and passes over the pulley on the car, finally attaches to a block of mass m. neglect all the friction.

(a) Draw free-body diagram for the cart and the block. Write down the equations of motion of the cart and the block.(6%)

(b) The length of the string is a constant, show that $a_y = 2a_x$, where a_y is the acceleration of the block along y axis, and a_x is the acceleration of the cart.(2%)

(c) Solve the equations of motions to find the accelerations of the block and the car, and what is the tension of the string.(2%)

10%(2): Consider a chain hangs over a table length b on one the table and length a hang on the other side. (see Fig.2)

(a)Find the speed at instant when the chain just slide off the table.(5%)

(b)Show that the time taken for the chain to slide off is given by the integral

$$T = \sqrt{\frac{a+b}{g}} \int_0^b \frac{1}{\sqrt{2ax + x^2}}\, dx \qquad (5\%)$$

10%(3): Consider the object shown in Fig.3, two identical disk with radius R was connected by a axle of radius r, A string is wrapped several times around axle, and a constant force F is applied to the string, suppose the motion of the object is rolls without slipping. Show that if $\theta < \cos^{-1}\frac{r}{R}$, the object will moves forward, and if $\theta > \cos^{-1}\frac{r}{R}$, the object will moves backward.

10%(4): For ideal gas, show that

$$C_P = C_V + R$$

where C_P is the molar heat capacity at constant pressure,C_V is the molar heat capacity at constant volume, and R is gas constant.

10%(5): Fig.4 shows a Venturi tube, used to measure the speed of air flow. A air flows through the tube, the cross section area at points 1 and 2 are A_1 and A_2, and the velocities of fluid at points 1 and 2 are v_1 and v_2 respectively, the height difference of the mercury is h. Show that the velocity of fluid at the points 1 and 2 are

$$v_1 = A_2\sqrt{\frac{2\rho_m g h}{\rho_a(A_1^2 - A_2^2)}}, \qquad v_2 = A_1\sqrt{\frac{2\rho_m g h}{\rho_a(A_1^2 - A_2^2)}}$$

where ρ_m,ρ_a are the mass density of the mercury and the air respectively.

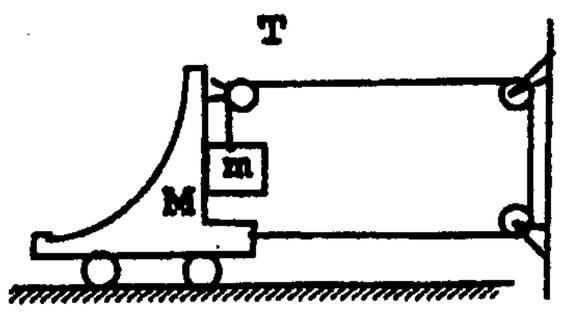

Fig-1

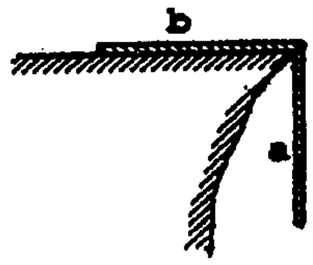

Fig-2

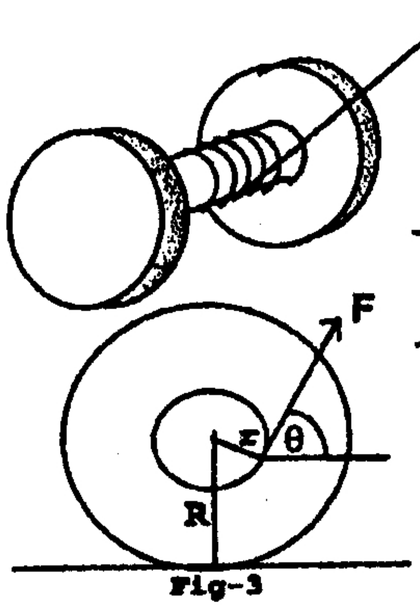

Fig-3

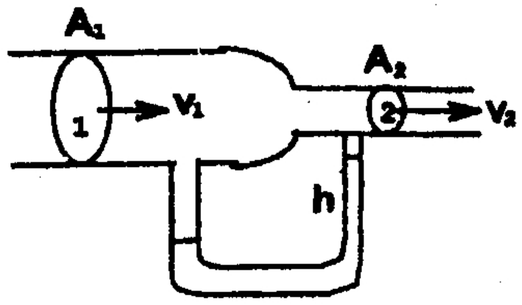

Fig-4

（背面仍有題目,請繼續作答）

10%(6): (a) State Gauss's law.(3%)

(b) The electric field can expressed in rectangular coordinate as $\vec{E} = \hat{i}(2x^2 + 5)\ C/N$. Find the net charge contained in the cubic as shown in the Fig.5.(7%)

10%(7): In Fig.6, An infinity wire $\overline{AB}$ carry a current I, the current is upward and increasing steadily at a rate $\mathrm{d}i/\mathrm{d}t$. Beside the wire, there is a rectangular loop with sides ℓ and w, and two sides of the loop parallel to the wire. Find the magnetic flux passing through the loop, and what is the induced emf in the loop?

10%(8): Fig.7 shows the Young's double slits experiment, the separation between two slits is d, the wavelength of the incident light is λ, there are interference pattern on the screen.

(a) Show that the positions of center of the dark fringes are given by

$$d\sin\theta = (m + \frac{1}{2})\lambda \qquad \text{(m is an integer)} \qquad (4\%)$$

(b) Sow that the intensity of the fringes at screen is given by

$$I = I_o \cos^2\left(\frac{\pi d \sin\theta}{\lambda}\right)$$

where I_o is the intensity at the center of the screen O. (6%)

10%(9): Monochromatic light of wavelength 450nm($1\text{nm} = 10^{-9}m$) is incident on a clean Na surface of work function $\phi = 3.7 \times 10^{-19}J$. Determine

(a) the energy of a photon of this light.(Planck's constant $h = 6.63 \times 10^{-34}J \cdot S$)(2%)

(b) the maximum kinetic energy of the emitted electrons.(3%)

(c) the threshold frequency for Na.(3%)

(d) the magnitude of the momentum of a photon in the incident light.(2%)

10%(10): A particle of mass m is confined in an infinity potential well between $0 \le x \le L$, that is

$$U(x) = \begin{cases} 0 & \text{for } 0 \le x \le L \\ \infty & \text{otherwise} \end{cases}$$

(a)Use the Schrödinger equation to find the possible energies of the particle.(5%)

(b)If the particle is in ground state, what is the probability of finding the particle lies between the interval $0 \le x \le \frac{L}{3}$.(5%)

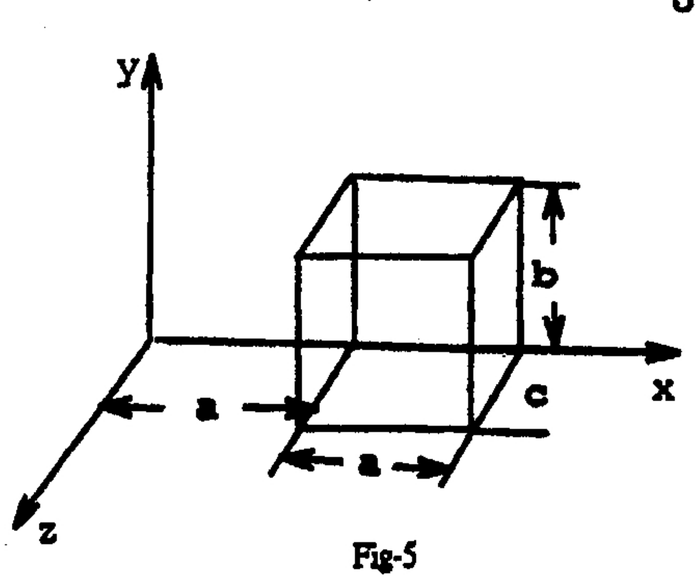

Fig-5

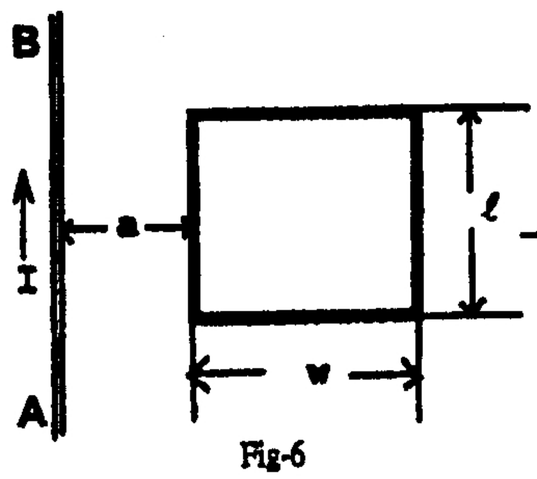

Fig-6

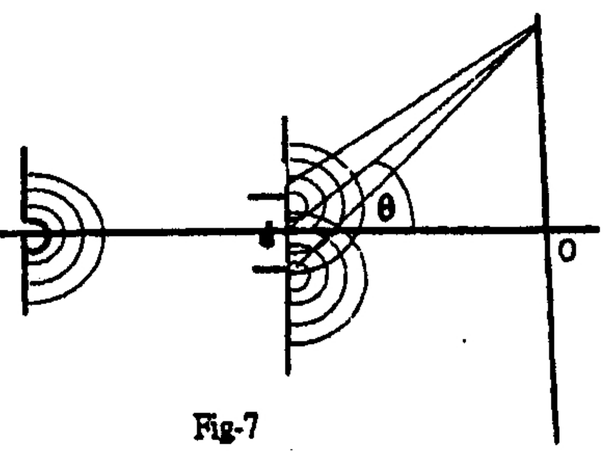

Fig-7