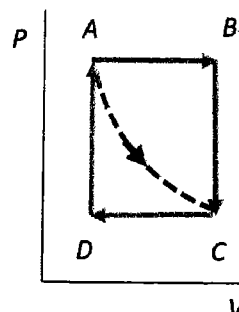計算與申論題（計算題應詳列計算過程，無計算過程者不予計分）

一、(8%) If a bullet of mass m is fired from a gun into a fixed block of mass M, it penetrates the block to a depth d_1. This block (with a bullet inside it) is then put on a horizontal surface, and a second bullet is fired into the block. To what depth will that bullet penetrate the block

(a) (5%) if the surface is frictionless and

(b) (3%) if the surface is not frictionless and the block moves a distance d_2 before it stops. (Assume that the kinetic friction force between the surface and the block is the same as that between the bullet and the block.)

二、(12%)　Please derive (a) (4%) Kepler's second law and (b) (4%) Kepler's third law for a circular orbit of radius r and period T. (c) (4%) If the gravitational force between masses M and m were $G'Mm/r^3$, with G' the proportional constant and r the distance between two masses, how would the Kepler's second and third laws be modified?

三、(14%) A hanging rigid object of mass m oscillates slightly about a fixed axis at O, which is a distance l from the center of mass CM. Let I be the moment of inertia of that object and g the gravitational acceleration. (a) (4%) What is the torque of the gravitational force on the axis at O at the angle θ shown in the Figure? (b) (5%) What is the period of the oscillation? (c) (5%) If the total mass is accumulated at CM, express that period only in terms of l and g (without m and I).
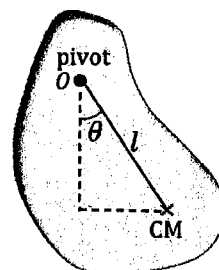
四、(16%) In the pressure-volume diagram, when an ideal gas moves from A to C along the dashed path, the change in its internal energy is -36 J. (a) (4%) If the energy added to the gas by heat through path ABC is $+188$ J, what is the work done on the gas from A to B? (b) (4%) If the pressure at A is 32 times that of C, what is the energy exchanged with the surroundings by heat as the gas goes along path CDA? (c) (4%) If 67 J is added to the gas by heat as it goes from D to C, what is the change in internal energy in going from D to A? (d) (4%) Suppose the molar specific heat at constant volume of the gas is $C_V = 3R/2$, with the gas constant R. If the dashed path from A to C is an adiabatic process, what is the ratio V_C/V_D between the volume V_C at C and V_D at D? (Note: $\overline{AB}$ and $\overline{CD}$ are horizontal lines, while $\overline{BC}$ and $\overline{DA}$ are perpendicular lines.)

注意:背面有試題

五. (15%) The Poynting vector of the electromagnetic wave is $S = (E \times B)/\mu_0$ with μ_0 the permeability of the free space. (a)(5%) Show that the dimension of S is energy/area/time. (b)(10%) Prove that the magnitude of the Poynting vector is given by $S = c(\epsilon_0 E^2 + B^2/\mu_0)/2$ with c the speed of light and ϵ_0 the permittivity of the free space.

六 (15%) Two capacitors, $C_1 = 50.0\ \mu F$ and $C_2 = 10.0\ \mu F$, are connected in parallel and charged with a 200-V power supply. (a)(5%) Draw the circuit diagram. (b)(5%) Calculate the charge stored in each capacitor. (c)(5%) Calculate the energy stored in each capacitor.

七 (15%) Let us consider the RL circuit shown below. When the switch S is closed at $t = 0$, the current $I(t)$ will flow in clockwise direction. (a)(5%) Write down the differential equation for $I(t)$. (b)(10%) Calculate the current at $t = 10.0\ \text{ms}$ for $R = 16.0\ \Omega$, $L = 80.0\ \text{mH}$, and $\mathcal{E} = 40.0\ \text{V}$. Note that $e^{-2} \approx 0.14$.

八 (5%) What is the radiation pressure?