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General Physics I, Final 1
PHYS10400, Class year 99
01-13-2011

SN:_____, Name:_____

ABSOLUTELY NO CHEATING!

Note: This is a close-book examine. You can use pencil or any pen in answering the problems. Dictionary and Calculators are allowed.

The followings are some useful mathematics you may use without proof in answering your problems.

$\sin x = x - \frac{1}{3!}x^3 + \frac{1}{5!}x^5 - \ldots..$ Time average $\overline{x(t)^n} = \langle x(t)^n \rangle = \frac{1}{T}\int_0^T x(t)^n dt$

For a second order differential equation, $\frac{d^2x}{dt^2} + ax = 0$, the general solution of this equation is $x(t) = x_0 \cos(at + \phi)$, where x_0 is the maximum, and ϕ is the phase angle.

$N_A = 6\times10^{23}$, R = Gas constant= 8.31 J/mole K, room temperature =300K, 1atm=1.01×105 Pa.

$\overline{v_x} = \frac{v_{rms}}{\sqrt{3}}$ for ideal gas.

Problems (9 Problems, total 100%)

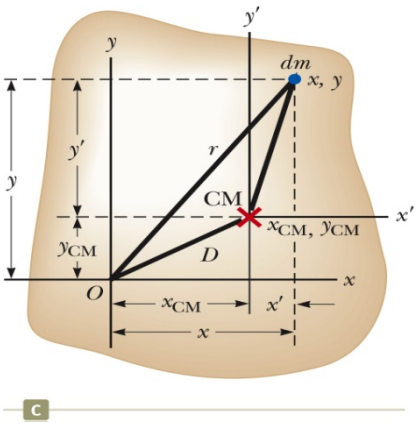
1. **Adiabatic Process**: (10%) Prove that for an adiabatic expansion of an ideal gas, PV^{γ}=constant, where $\gamma = C_p/C_v$.

2. **Rotational Inertia**: What is the rotational inertia of a solid cylinder of radius ***R***, density ρ and length ***L*** rotating along its long axis? (10%)

3. **Escape Velocity:** (10%) If the radius of the earth is R_E, the mass of our earth is M_E. You through a stone of mass m with initial velocity V_i vertical up and reach a maximum height of H. (a) What is the initial velocity? (b) if you wish to through the stone vertically up so it will reach infinite, what is the initial velocity of the stone should be?

4. **Simple Harmonic Oscillator**: (10%) Take a spring of force constant ***k***, with a mass ***m*** attached to the end. This oscillator is allowed to oscillate freely with maximum amplitude **A**. Prove that the total energy of a simple harmonic oscillator is constant.

5. **Parallel Theorem**: Consider an object of mass M as shown in the figure to the right. If the rotational inertia about its center of mass is $\mathbf{I_{cm}}$, what is the rotational inertia when it is set to rotate at a fixed axis located at a distance **D** from the center of mass of the object? Prove it (10%)



6. **Wave Equation**: (10%) In the same figure used for the previous problem. If you focused on this section of the string, you can find the mass of the string is oscillating vertically (y-direction) that is it is perpendicular to the wave's travelling direction (say, to the right or in the +x direction). Let the same section, suppose the vibration of the string can be represented as a function ***y(x, t)***; a function of both ***x*** and ***t***. Prove that the wave equation describing this wave motion is $\frac{\mu}{T}\frac{\partial^2 y(x,t)}{\partial t^2} = \frac{\partial^2 y(x,t)}{\partial x^2}$. (註：本題題意不完整，漏放說明圖，因此本題不計分)

7. **Dulong-Petit law**: (10%) Dulong-Petit law applies to general solid phase of material at higher temperature. The molecular specific law of all solids reaches ***3R*** (***R*** is the gas constant) at high temperature. The law can be explained using the equipartition energy theorem; that is in each degree of freedom, the average energy shares $1/2k_BT$. Prove that $\mathbf{C_v=3R}$ in solid in high temperature.

8. **Entropy**: (a) Consider an ideal gas undergoes a free expansion from initial volume $\mathbf{V_i}$ to its final volume $\mathbf{V_f}$ at temperature **T**. What is the entropy change for this system? Next, consider a quasi-static reversible process where an ideal gas expands from volume $\mathbf{V_i}$ to $\mathbf{V_f}$, temperature $\mathbf{T_i}$ to $\mathbf{T_f}$. What is the entropy change n this system? (20%)

9. **Mean Free Path**: (10%) Mean free path means the average distance an ideal gas travels before its makes collision with another gas particle. If the diameter of the gas is ***d***, and there are total ***N*** gases particles in a large container that has volume ***V***. What is the mean free path of these gas particles?