所別：天文研究所碩士班 不分組 科目：普通物理

1. (20%) For an N particle system with total mass M and the center of mass located at $\vec{R}$, show that
   (i) The total kinetic energy can be written as $T = T_c + \frac{1}{2}M\left|\dot{\vec{R}}\right|^2$ where T_c is the total kinetic energy measured in center of mass system.
   (ii) The total angular momentum can be written as $\vec{L} = \vec{L}_c + M\vec{R}\times\dot{\vec{R}}$, where $\vec{L}_c$ is the total angular momentum for the center of mass system.
   (iii) If the force from ith particle acting on the jth particle is $\vec{F}_{ij} = f_{ij}\left(\vec{r}_i - \vec{r}_j\right)$ where f_{ij} is only the function of distance between ith and jth particles (i.e. $f_{ij} = f\left(\left|\vec{r}_i - \vec{r}_j\right|\right)$) and $f_{ii} = 0$, show that both the total momentum and the total angular momentum of the system are conserved if there is no external force or torque acting on the system

2. (15%) A charged particle with charge q and mass m initially located at position $\vec{r}_0 = a\hat{x}$ with velocity $\vec{v}_0 = v_0\hat{y}$ is influenced under a uniform magnetic field $\vec{B} = B\hat{z}$.
   (i) Write down the equation(s) of motion.
   (ii) Solve the equation(s) in (i)
   (iii) Use the results of (ii) to derive the trajectory of the particle.

3. (20%) Two charged particles with charge q and $-q$ are located at $\frac{a}{2}\hat{z}$ and $-\frac{a}{2}\hat{z}$ respectively shown as Figure 1.
   (i) Show that the electrostatic potential at position $\vec{r}$ is proportional to $\frac{\vec{p}\bullet\vec{r}}{|\vec{r}|^3}$ for $|\vec{r}| >> a$, where $\vec{p} = qa\hat{z}$.
   (ii) What is the electric field at $\vec{r}$ if $|\vec{r}| >> a$?

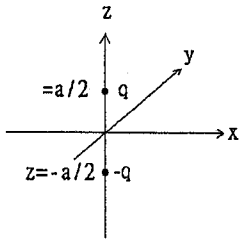

Figure 1

4. (20%) Three tanks of monatomic ideal gas with identical initial temperature T, volume V and pressure P expand to $2V$ through the following three different processes respectively:
   (a) Isothermal,
   (b) Adiabatic
   (c) Free expansion.
   Please calculate the following quantities for these three systems:
   (i) Heat flow into the systems (ΔQ)
   (ii) Works done to the environment (ΔW)
   (iii) Internal energy changes of the systems (ΔU)
   (iv) Entropy changes of the systems (ΔS)
   (v) Final temperatures

注意：背面有試題

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5. (10%) Two simple harmonic systems with mass M and force constant k are coupled with a spring whose force constant is κ shown as Figure 2
   (i) Calculate the eigenfrequencies of the system
   (ii) Find the normal modes of the motions for the system.

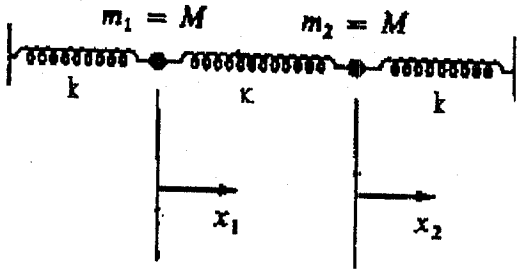

Figure 2

6. (15%) An unpolarized light beam with intensity I_0 passes through three perfect linear polaroid filters, A B and C whose polarization directions are :
   A: parallel to x-axis;
   B: 45° respected to x-axis and
   C: parallel to y-axis,
   shown as Figure 3.
   (i) What is the intensity of the transmitted light beam?
   (ii) If the filter B is removed, what is the intensity of the transmitted light beam?

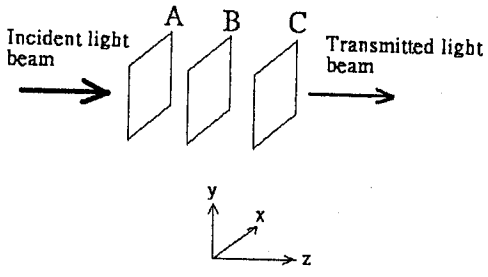

Figure 3