1. (a) Find the eigenfrequencies of the coupled oscillators shown below. Both particles have the mass of $M$, $\kappa$ and $\kappa_{12}$ are the force constants of the springs, and $x_1$ and $x_2$ are measured from the positions of the equilibrium. (10%) (b) Describe the motion of the particles associated with the eigenfrequencies. (10%)

![Coupled Oscillators Diagram]

2. (a) Earth's rotation axis is not fixed in Space. For example, it is pointing approximately to the Polaris (北极星) now, and was pointing to Vega (織女星) about 13,000 years ago. Explain how this happens. (5%) (b) Describe how you estimate the radius of Earth without the help from satellites. (5%)

3. The plot below shows the information of the electronic specific heat $C$ of a moderate-coupling superconductor with $T_c=6.4$ K. The solid line represents the superconducting state data below the transition temperature $T_c$, and the dashed line does the normal state data. (a) How do you use this plot to find out the entropy $S(T)$? (10%) (b) There is a specific jump (discontinuity of $C$) at $T_c$ for the phase transition. Why? (10%)

![Specific Heat Plot]

\[ C(T) \text{ (mJ/mol K)} \]

\[ T \text{ (K)} \]
4. (a) Explain why usually a solid expands with increasing temperature. (5%) (b) Estimate the numbers of the air molecules in the classroom which you are sitting in. (5%)

5. Calculate the self-inductance $L$ of a coaxial line in the expression of $a$ and $b$. Assume that the current $I$ flows uniformly through the conductors and ignore the thickness of the outside cylinder ($b\approx c$). (Hint: $L=\Phi$, where $\Phi$ is the magnetic flux.) (10%)

6. A charge $q$ is placed at the center of a cubic with the edge length of $a$. Find out the electric flux through one of its square faces with area $a^2$. (10%)

7. (a) Demonstrate that a magnetic moment $\vec{\mu}$ in a uniform magnetic field $\vec{B}$ experiences a torque $\vec{\tau} = \vec{\mu} \times \vec{B}$. (10%) (b) Show that the potential energy for a magnetic moment $\vec{\mu}$ in a uniform magnetic field $\vec{B}$ is $U = -\vec{\mu} \cdot \vec{B}$. (10%)