

中央大學八十九學年度碩士班研究生入學試題卷

物理學系 不分組 科目： 古典物理 共 1 頁 第 1 頁

- (25 pts) Assume that the earth is a sphere of radius R with a uniform mass density ρ . We dig a tunnel from the north pole through the earth center to the south pole. Now we freely release a ball with mass m at the north end of the tunnel. (1) Please qualitatively describe the movement of the ball. (2) Please find the equation for the movement. (3) Try to solve the equation. (Hint: assume the gravitational constant k .)
- (25 pts) A thin uniform circular metal disk lies on an infinite conducting plane. A uniform gravitational field is oriented normal to the plane. The weight of the disk is W . Initially the disk and the plane is uncharged; charge is slowly added to the conducting plane and the disk. What value of charge density is required to cause the disk to leave the plate? (Hint: assume the uniform charge density and ignore the edge effect.)
- (3 points) Consider the small amplitude motion of a pendulum with mass M and length L . Show that the angular frequency of the vibration is $\sqrt{g/L}$ where g is the gravitational acceleration.
 - (7 points) Now the pendulum is immersed in water, so that the viscous force f is proportional to its velocity $f = -bv$. Calculate the frequency of the vibration. What is the critical damping strength b_c ?
 - (10 points) Consider two identical pendulums with mass M and length L , immersed in water as 3.(b) above. Two pendulums are connected by a spring with a force constant k . The natural length of the spring is the same as the distance between the two pendulums at the top. Calculate the frequencies of the two eigenmodes (normal modes).
 - (10 pts) Discuss how the frequencies change with k and b .
- (8 pts) For the idea gas with a constant heat capacity C_V . Show that in the adiabatic process, the pressure P and the temperature T follow the equation

$$TP^m = c$$

where c and m are constants.

- (12 pts) For a real gas, assume that the gas obeys the van der Waals' equation

$$P = \frac{NRT}{V - Nb} - \frac{aN^2}{V^2}$$

where N is the number of mole, a and b are constants. R is the gas constant. The heat capacity C_V is still a constant. Now the internal energy E depends on the volume, as $(\partial E / \partial V)_T = -aN^2/V^2$. Show that the entropy change $S_f - S_i$ of a general process, from V_i, T_i to V_f, T_f , is