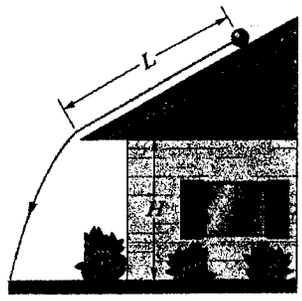
1. Calculating the Rotational Inertia and Rolling (10+10%)

In figure, a solid cylinder of radius 10 cm and mass 12 kg starts from rest and rolls without slipping a distance L = 6.0 m down a roof that is inclined at angle $\theta = 30^0$.

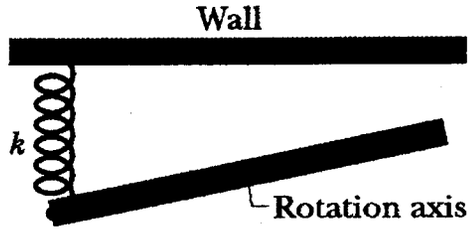


(a) Please find the rotational inertial of cylinder about central axis.

(b) The roof's edge is at height H = 5.0 m. How far horizontally from the roof's edge does the cylinder hit the level ground?

2. Pendulum (15%)

In the overhead view of figure, a long uniform rod of mass 0.600 kg is free to rotate in a horizontal plane about a vertical axis through its center. A spring with force constant k = 1850 N/m is connected horizontally between one end of the rod and a fixed wall. When the rod is in equilibrium, it is parallel to the wall. What is the period of the small oscillations that result when the rod is rotated slightly and released?



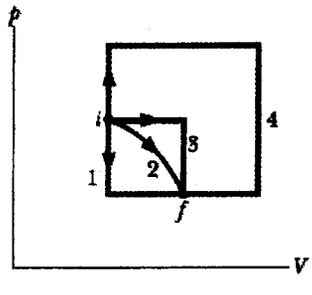
3. Change in Entropy (15+5%)

(a) Please prove that when an ideal gas changes reversibly from an initial state with temperature T_i and volume V_i to a final state with temperature T_f and a final volume V_f, the change in entropy of the gas is

$$\Delta S = S_f - S_i = nR \ln \frac{V_f}{V_i} + nC_V \ln \frac{T_f}{T_i},$$

where C_v is the molar specific heat at constant volume. n is the moles number of gas system and R is the gas constant.

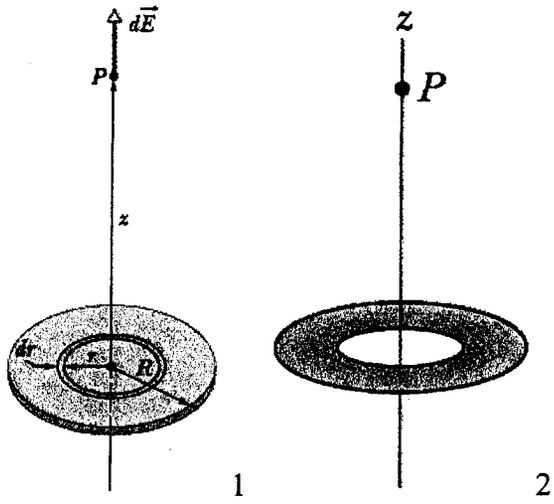
(b) An ideal gas, in contact with a controllable thermal reservoir, can be taken from initial state i to final state f along the four reversible paths in figure. Rank the paths according to the magnitudes of the resulting entropy changes of (1) the gas, (2) the reservoir, and (3) the gas–reservoir system, greatest first.



（背面仍有題目，請繼續作答）

4. The Electric Field Due to a Charged Disk (15+5 %)

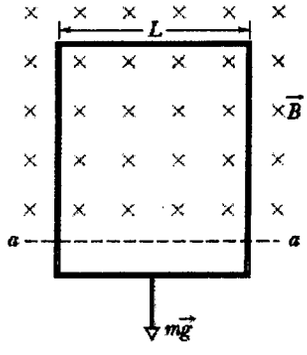
(a) Fig.1 shows a circular plastic disk of radius R that has a positive surface charge of uniform surface density σ on its upper surface. What is the electric field at point P, a distance z from the disk along its central axis? [Hint: The ring shown has radius r and radial width dr. It sets up a differential electric field $d\vec{E}$ at point P on its central axis.]



(b) As shown in Fig.2, a ring of the same outer radius R but with inner radius $R/2$. Assume that the ring will have the same surface charge density as the original disk. If you switch disk to the ring, by what percentage will you decrease the electric field magnitude at P?

5. Induction (10%)

In figure, a long rectangular conducting loop, of width L, resistance R, and mass m, is hung in a horizontal, uniform magnetic field that $\vec{B}$ is directed into the page and that exists only above line aa. The loop is then dropped; during its fall, it accelerates until it reaches a certain terminal speed v_t. Ignoring air drag, find an expression for v_t.



6. Diffraction by a Double Slit (15%)

(a) In a double-slit experiment, what ratio of the slit separation, d, to the slit width, a, causes diffraction to eliminate the fourth bright side fringe?

(b) What other bright fringes are also eliminated?