普通物理

(useful constants: $e = 1.60 \times 10^{-19}$ C; $m_e = 9.11 \times 10^{-31}$ kg;
$c = 3.00 \times 10^{8}$ m/s; $h = 6.63 \times 10^{-34}$ J·s)

1. Units and constants

(a) The permittivity of free space $\varepsilon_0 = 8.85418781762 \times 10^{-12}$ $C^2/N \cdot m^2$ in Gauss' law is exact with no uncertainty. Why? (5%)

(b) In the SI units, the base unit used is **A** (ampere) for electric current instead of **C** (coulomb) for electric charge. Why? (5%)

2. Explain the following terms:

(a) Maxwell displacement current in generalized Ampere's law. (5%)

(b) Eddy current from motional emf in Faraday's law. (5%)

3. A RLC oscillator circuit is transformer-coupled to a transmission line with an electric dipole type antenna.

(a) What is the resonance angular frequency ω_r if $2L/C \gg R^2$ (5%)

(b) If the dipole axis is along the z-axis, what is the direction of magnetic field **B** for the radiated electromagnetic wave at point P in the x-axis ($r \gg$ wavelength λ)? (5%)

4. A He-Ne laser generates coherent red beam with wavelength $\lambda = 633$ nm and peak (maximum) power $P = 1$ mW.

(a) If the laser beam diameter $d = 1$ mm, what is the (average) beam intensity I? (5%)

(b) When the laser beam incidents into a water with index of refraction $n = 1.3$, what is the laser color observed by a person in water? (5%)

5. Hsinchu's Synchrotron Radiation Research Center has a 1.5 GeV electron synchrotron

(a) What is the Lorentz factor $\gamma \equiv 1/[1 - (v/c)^2]^{1/2}$ of 1.5 GeV electrons with speed v? (5%)

(b) The synchrotron radiation provides a "light" source with maximum radiation energy of 15 keV. Can these 15 keV photons be used determine the Cu crystal structure with typical Cu-Cu spacing of 0.1 nm? (5%)

6. (10%) An airplane starts to take off and its velocity is 0 at $t = 0$. The acceleration of the airplane is described as the following:

$$\vec{a}(t) = \begin{cases} (t^2)\hat{i} - (t)\hat{j} & \text{for } 0 \le t \le 2 \\ (2)\hat{i} + (2t)\hat{k} & \text{for } 2 \le t \le 10 \end{cases}$$

where $\hat{i}$, $\hat{j}$, and $\hat{k}$ are the units vectors in the x, y, and z axes. Please find (a) its velocity at $t = 5$ and (b) the displacement during this 10 seconds.

7. (10%) A sphere of mass M and radius R has a spherical cavity of radius $R/2$ in it. The surface of the cavity touches the outside surface of the sphere as shown in Figure 1. Define x and y axes as the horizontal and vertical directions. The origin (0, 0, 0) is at the center of M and the coordinate (0, $R/2$, 0) is at the center of the cavity. A point mass m locates at (d, 0, 0). Please find the gravitational forces in vectors on m (a) for $d > R$ and (b) for $d < R$.

8. (10%) With the same conditions as those in Question 7, please find the potential energies of m locating (a) at (R, 0, 0) and (b) at (0, $R/2$, 0)?

9. (12%) One mole of ideal mono-atomic gas goes through the processes as the P–V (pressure–volume) diagram in Figure 2. $a \to b$ is an isothermal process. $b \to c$ and $c \to a$ are two straight lines. (a) Please find the heats absorbed by the gas and the changes in kinetic energy of the gas during $a \to b$, $b \to c$, and $c \to a$. (There should be 6 answers).

10. (8%) With the same conditions as those in Question 9, what are the changes in entropy during $a \to b$ and during $c \to a$?

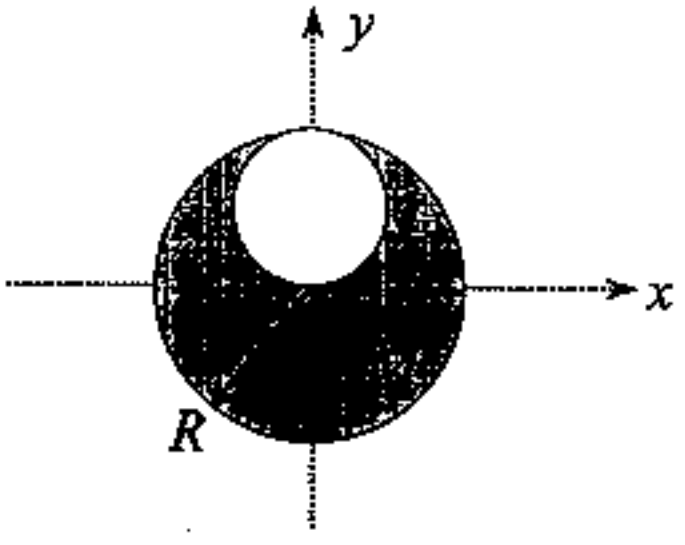

Figure 1

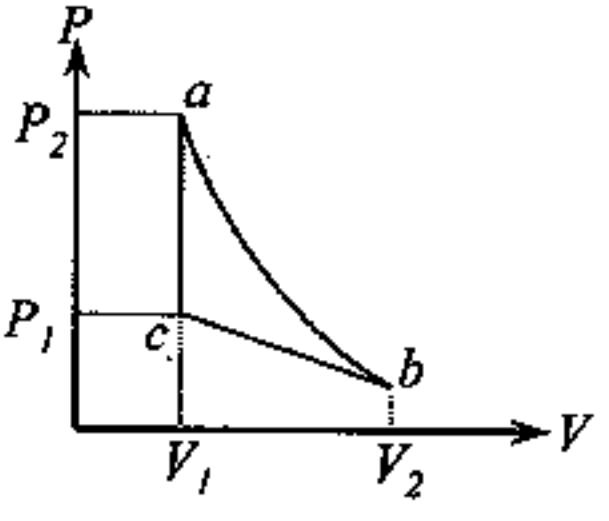

Figure 2