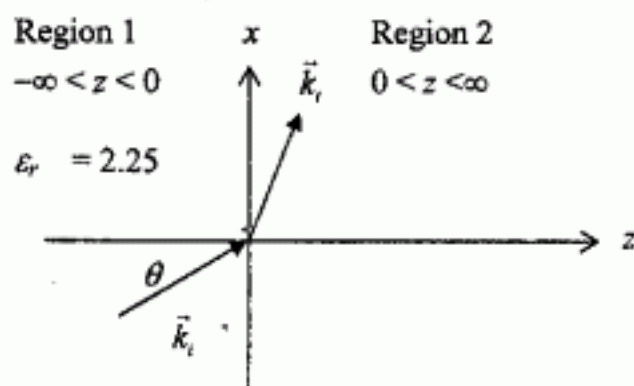1. A spherical conducting shell has an outer and an inner surface with $+Q$ charges reside at its center. Select the correct answers from the following choices. (a) The electrostatic field strength distribution is zero everywhere outside the shell. (b) The electrostatic potential decreases from the inner surface to the outer surface. (c) The surface charge density is smaller in magnitude at the outer surface than at the inner surface. (d) Gaussian law can not be applied in the region between outer and inner surfaces. (e) The electrostatic field strength is zero in the region between outer and inner surfaces. (multiple choices, 答錯倒扣)   (10%)

2. A capacitor microphone (麥克風) is shown in the figure below. A very thin metal foil and a hard metal plate form a capacitor. The metal foil vibrates up and down when a sound wave strikes it. The voltage difference $\triangle V$ is fed to an amplifier and then a loud speaker. Explain and analyze the working principle of the microphone in detail. At least, you must explain how would $\triangle V$ proportional to the sound wave amplitude.   (15%)
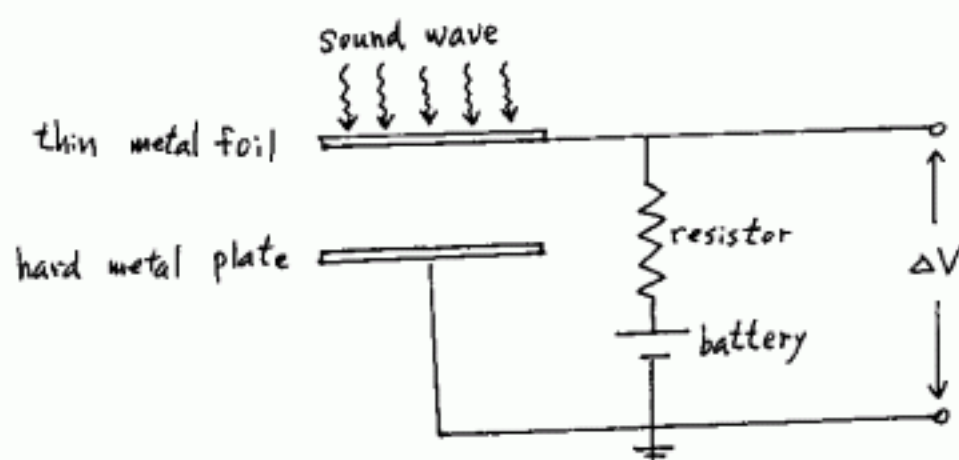
3. A uniform magnetic flux density $B=2$ webers/m^2 exists within an iron core (μ $=1000\,\mu_0$). If an air gap is cut through the core with the parallel cutting surfaces oriented 30° with respect to the direction of B, find the magnitude and direction of B in the gap. (10%)

4. Consider the following scattering configuration. A nonmagnetic medium with a relative permitivity of $\varepsilon_r = 2.25$ occupies the space from $z = -\infty$ to $z = 0$, labeled as Region "1". Region "2", beyond the boundary $z = 0$ up to $z = \infty$, is a vacuum. A TE polarized plane wave of frequency $= 3 \times 10^{14}$ Hz is incident on the material-vacuum boundary, as shown below. Assume that at $t = 0$, $x = y = 0$ the incident plane wave has an electric-field amplitude of $E_i = E_{i0} \cos\phi_i$ immediately before the $z = 0$ plane and the transmitted wave has that of $E_t = E_{t0} \cos\phi_t$ immediately after the $z = 0$ plane, where all the quantities in the expressions are real numbers. Answer the following questions with MKSA units. Useful numbers: $\sqrt{2.25} = 1.5$, $\sin 30° = 0.5$, $\cos 30° = 0.87$,

$\sin 45° = \cos 45° = \dfrac{1}{\sqrt{2}} = 0.71$.

Region 1　　　x　　Region 2
$-\infty < z < 0$　　　$\vec{k}_t$　　$0 < z < \infty$

$\varepsilon_r = 2.25$

θ

$\vec{k}_i$

→ z

Let the plane wave has an incident angle of $\theta = 30°$ with respect to the z axis.

i. What is the wavelength along the wave propagation direction in Region 1? (2%)

ii. What is the angle between the transmitted wave and the z axis? (3%)

iii. What is the wave vector of the incident wave $\vec{k}_i$? (5%)

iv. What is the wave vector of the transmitted wave $\vec{k}_t$? (5%)

v. Write the expression of the incident electric-field intensity vector $\vec{E}_i(t, x, y, z)$. (5%)

vi. Write the expression of the incident magnetic-field intensity vector $\vec{H}_i(t, x, y, z)$. (7%)

vii. If now the plane wave has an incident angle of $\theta = 45°$ with respect to the z axis, what is the expression of the transmitted electric-field intensity vector $\vec{E}_t(t, x, y, z)$? (8%)
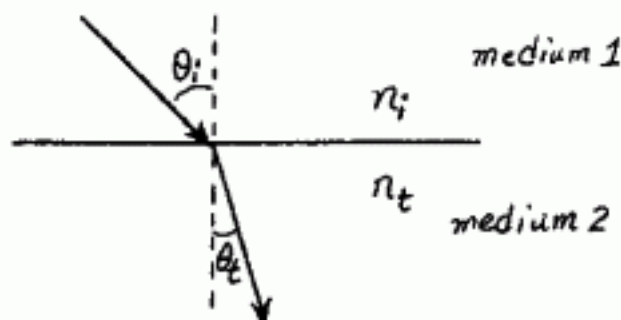
5.(I)

The amplitude reflection coefficient for a p wave incident upon the interface between media 1 and 2 (see the figure right below) is

$$r = \frac{n_t \cos\theta_i - n_i\cos\theta_t}{n_t\cos\theta_i + n_i\cos\theta_t}$$

(a) What are the definitions of s wave and p wave ? (4%)
(b) Compute the amplitude transmission coefficient. (5%)
(c) Consider the following figure, which depicts a p-wave ray being multiply reflected by a transparent dielectric layer with a thickness of d.
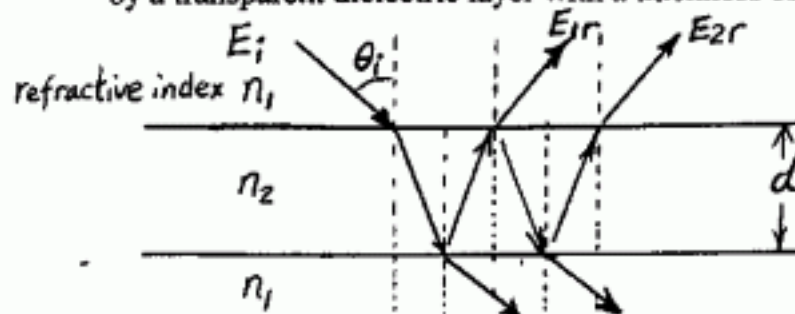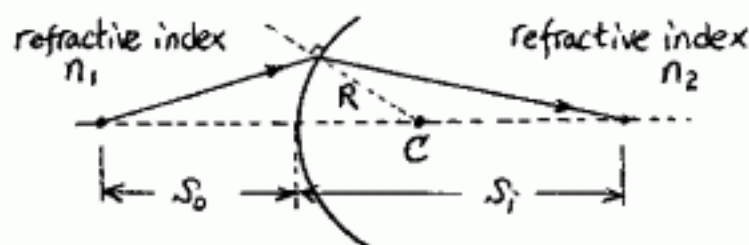

Suppose the field associated with the incident ray is E_i. What are E_{1r} and E_{2r} upon reflection? Express them in terms of d, n_1, n_2, E_i and etc.　(6%)

(II)
The lensmaker's equation for a spherical surface(formed between two media with refractive indices n_1 and n_2 ; see the figure below) is

$$(n_1/s_o) + (n_2/s_i) = (n_2-n_1)/R$$

Consider a spherical thin lens made out of a material with the refractive index n_g, as shown below. What is the focal length of such a lens if it is immersed in a liquid of refractive index n_0 ?　You need to derive an expression for the focal length of such a lens in terms of n_o, n_g, R_1 and R_2.　(15%)