注
意：背面有試題

1. A plane wave with optical frequency $\omega = 4 \times 10^{15}$ rad/s impinges normally on the silver-glass film structure as shown in Fig. 1. Assume that the conductivity of silver $\sigma = 6 \times 10^7 (\Omega \cdot m)^{-1}$, the refractive index of glass n=1.5, and $\mu = \mu_0$ applies to all materials. Find the thickness of the silver layer so as to produce half-reflection and half-transmission characteristics. (10 pts)
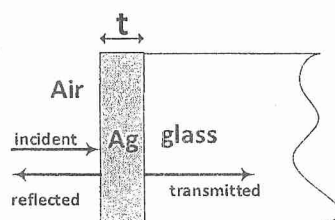

Fig. 1

2. Calculate the TE and TM modes (specifying the mode designations and the corresponding cutoff frequency) that can propagate in a metal-dielectric-metal (MDM) parallel-plate waveguide with water between the two metal walls. The distance between the two metal slabs is 1 μm and the free-space wavelength is 1.55 μm. The dielectric constant of water at λ=1.55 μm is considered real and equal to 1.77. Consider the metal to be a perfect electrical conductor. (10 pts)

3. (a) Write down the time dependent dipole moment $\vec{p}(t)$ for a rotating electric dipole lying on the x-y plane, as shown in Fig. 2. (10 pts)

(b) Express the potential $V(r,\theta,\phi,t)$ and $\vec{A}(r,\theta,\phi,t)$ produced by the electric dipole at a distant point $P(r,\theta,\phi)$. Note that $d \ll \omega/c \ll r$; θ and ϕ are the polar and azimuthal angle, respectively. (5 pts)
(c) Find the electric and magnetic field of the rotating dipole at P. (5 pts)
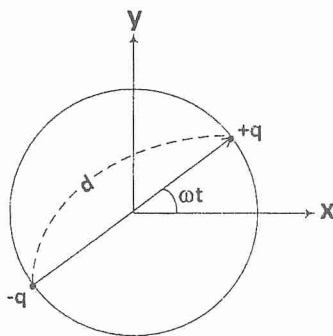(d) Find the Poynting vector and plot the intensity profile of the radiation. (10 pts)

Fig. 2

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4. (15 pts) 請解釋以下名詞的意義

(請注意：此題的要求是解釋名詞的物理意義，而不是將名詞譯為中文)

(a) isotropic medium; (b) dispersive medium; (c) Brewster angle; (d) critical angle
(e) gauge transformation.

5. (a) (5pts) 一個物質介質的折射率 (index of refraction) n 與它的相對介電常數 (relative permittivity) $\varepsilon_r = \varepsilon / \varepsilon_0$ 以及相對磁導率 (relative permeability) $\mu_r = \mu / \mu_0$ 的關係是什麼？

(b) (15pts) 在 "光是電磁波" 的假設下，請分別寫下物質介質中與真空中的 Maxwell 方程組，並從它們推導出兩組波方程式，然後比較這兩組波方程式並根據折射率的定義證明上述 (a) 中所提到的關係。

[Hint: 對於向量場 $\vec{V}(\vec{r},t)$，你可以套用這個公式：$\nabla \times (\nabla \times \vec{V}) = \nabla (\nabla \cdot \vec{V}) - \nabla^2 \vec{V}$]

6. (15 pts) 已知水 (water) 的相對介電常數在室溫，低頻 (小於 1kHz) 時大約是 80，但在可見光波段大約為 1.77。請根據水分子的電偶極 (electric dipole) 特性做簡單的分析，以對此相對介電常數的大幅度變化給出一個合理的解釋。