國立清華大學 107 學年度碩士班考試入學試題

系所班組別：聯合招生 (0598)

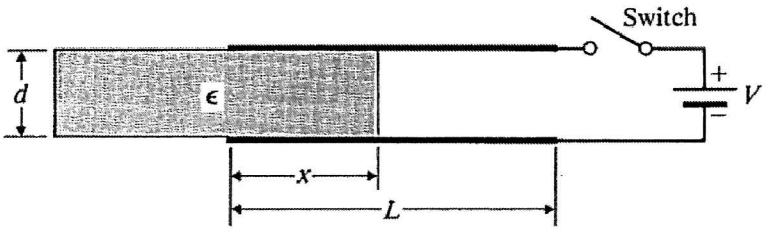
考試科目（代碼）：電磁學 (9803)

自由空間的電磁常數：

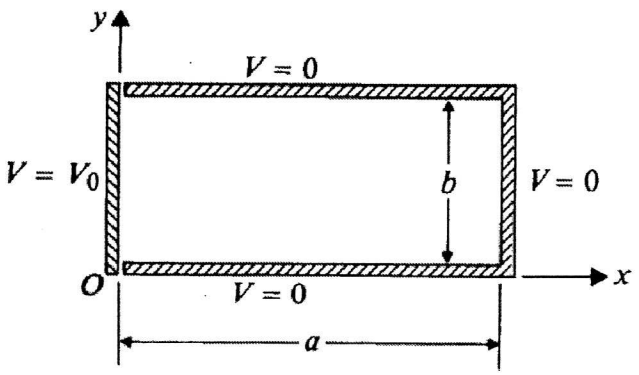
permittivity	$\epsilon_0 = \frac{10^{-9}}{36\pi}$ F/m
permeability	$\mu_0 = 4\pi \times 10^{-7}$ H/m
light speed	$c = 3 \times 10^8$ m/s

注意事項：請以 SI 制單位回答下面所有問題

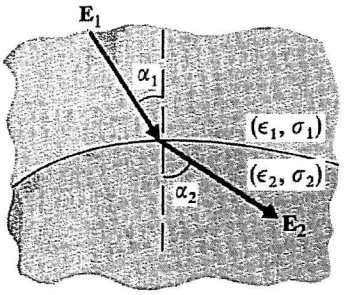
1 . A parallel-plate capacitor of width w, length L, and separation d has a solid dielectric slab of permittivity ϵ in the space between the plates. The capacitor is charged to a voltage V by a battery. Assume that the dielectric slab is withdrawn to the position shown in the figure and the vacuum permittivity is ϵ_0. Determine the force acting on the slab (a) with the switch closed, (b) after the switch is first opened. (10%)



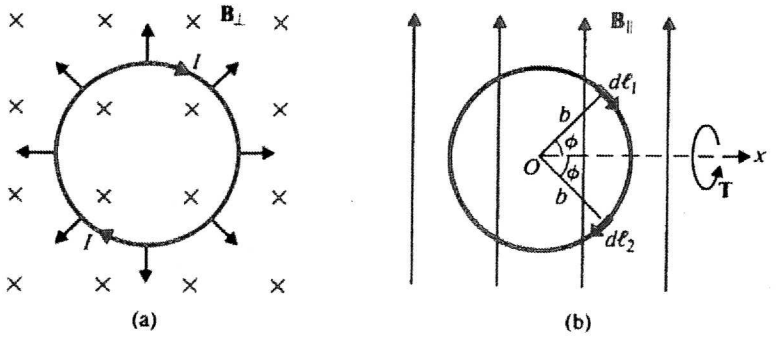
2. Consider the region enclosed on the three sides by grounded conducting planes shown in the figure. The end plate on the left is insulated from the grounded side and has a constant potential V_0. All planes are infinite in extent in the z-direction. Determine the potential distribution function $V(x, y)$ within the region. (20%)



3. Two lossy dielectric media with permittivities and conductivities (ϵ_1, σ_1) and (ϵ_2, σ_2) are in contact. An electric field with magnitude E_1 is incident from medium 1 upon the interface at an angle α_1 measured from the common normal (see figure below). Find the magnitude E_2 and angle α_2 of $\mathbf{E}_2$ in medium 2, and the surface charge density ρ_s at the interface. (10%)



4. Consider a circular loop of radius b and carrying a current I in a uniform magnetic field of flux density $\mathbf{B}$. It is convenient to resolve $\mathbf{B} = \mathbf{B}_\perp + \mathbf{B}_\parallel$ where $\mathbf{B}_\perp$ and $\mathbf{B}_\parallel$ are perpendicular and parallel to the plane of the loop, respectively. (a) Determine the magnetic force per unit length that tends to expand the loop. (b) Determine the total torque acting on the loop. (10%)



5. A conducting sliding bar oscillates over two parallel conducting rails in a sinusoidally varying magnetic field of flux density $\mathbf{B} = 0.1\cos\omega t\ \hat{z}$ T, as shown in the figure. The position of the sliding bar is given by $x = 0.5(1 - \cos\omega t)$ m and the rails are terminated in a resistance R=0.8 Ω. Find the current i. (10%)

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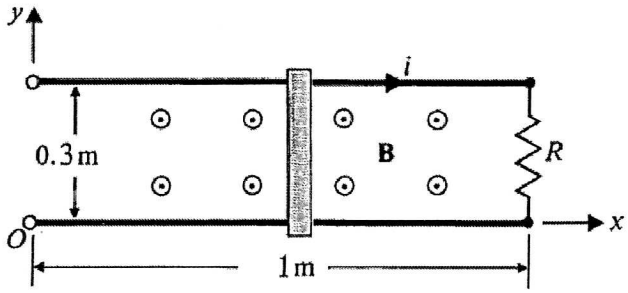

6. The electric field intensity of a linearly polarized uniform plane wave of frequency $f = 1\text{MHz}$ propagating in the z-direction in seawater. The constitutive parameters of seawater are $\epsilon_r = 72$, $\mu_r = 1$, and $\sigma = 4$ S/m. Explain that the seawater is a good conductor for the plane wave. Determine the attenuation constant α, the phase constant β, the intrinsic impedance η_c, the phase velocity u_p, the wavelength λ, and the skin depth δ. (10%)

7. Consider the parallel-plate waveguide of two perfectly conducting plates separated by a dielectric medium of thickness d with constitutive permittivity ϵ and permeability μ. The plates are assumed to be infinite in extent in the x and y directions. Let us suppose that TM waves propagate in the +x-direction. Determine the cutoff frequency for TM_n mode where $n = 0, 1, 2, 3, \ldots$. Explain furthermore that the TM_0 mode is a TEM mode. (10%)

8. Answer the following questions:

(a) Write the differential form of Maxwell's equations. (5%)

(b) Write Lorentz's force equation. State Biot-Savart law. State Lenz's law (5%)

(c) Define the terms "the electric scalar potential V" and "the magnetic vector potential **A**". What are their SI units? (5%)

(d) Define "Poynting vector **P**". What is the SI unit for this vector? Define the terms: reflection coefficient Γ and transmission coefficient τ. What is the relationship between them? (5%)