科目：電磁學B(5005)　　校系所組：中大光電科學與工程學系、照明與顯示科技研究所
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一、 True-False questions. For each correct answer you get 1 point, while for each incorrect answer, you lose 1 point. You can leave one or more questions unanswered, and in which case, you will neither gain nor lose points. Your total score for this problem will not be less than zero. Please fill in "T" or "F" in each box, or leave it blank as unanswered. (15%)

(a) There is no angle of incidence for which exactly 100% linearly polarized white light can be produced by reflection off a piece of glass.

(b) The Poynting vector for a standing EM wave at an instant may not be zero, but the time-averaged Poynting vector for a standing EM wave is always zero.

(c) A time-varying magnetic field can exist in the interior of a perfect conductor.

(d) Conduction and displacement current are out of phase for time-harmonic fields.

(e) There is no energy dissipation in a medium when the electric field $\vec{E}$ and the free current density $\vec{J}_f$ are out of phase by $\pi/2$ radians.

(f) A wave is incident at an angle θ, on a plate of dielectric backed by a perfect conductor. To avoid multiple reflections, the skin depth of the conductor should have a value of $\lambda/4$. (λ is the wavelength of the incident wave).

(g) When the magnetic flux through an open surface attached to a conducting loop is zero, there can not be an electromotive force induced in that loop.

(h) To perform half-reflection and half-transmission for the power of an incident light wave at normal incidence on the interface between two dielectrics, the ratio of the index of refraction should be ~ 5.83.

(i) Transverse electromagnetic waves can not exist in a single-conductor hollow (or dielectric-filled) waveguide of any shape.

(j) Two conducting wires with identical dimensions. The self-conductance will be the same even when they are made of different metals.

(k) Compared with a perfect reflector, sunlight exerts twice of the pressure on a perfect absorber.

(l) If a water wave travels at a speed that is proportional to the square root of its wavelength; the wave (phase) velocity of water wave is half of the group velocity.

(m) Polaroid sunglasses, with the transmission axis horizontal, can help to reduce the glare from puddles on the road.

(n) The radiation pattern of all linear binomial arrays sidelobeless.

(o) A circular optical fiber has no cutoff frequency.

a.☐ b.☐ c.☐ d.☐ e.☐ f.☐ g.☐ h.☐ i.☐ j.☐ k.☐ l.☐ m.☐ n.☐ o.☐

注意：背面有試題

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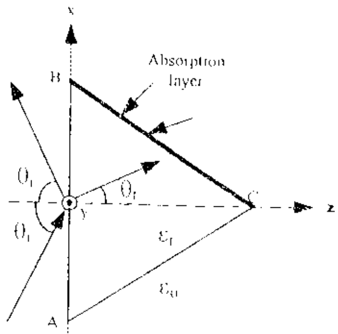
二、 A circularly polarized wave, with the average power density of $10\,\mathrm{mW/m^2}$, incidents onto one side of a triangular prism, whose cross-section is an equilateral triangle ($\overline{AB} = \overline{BC} = \overline{CA}$). The direction of propagation is perpendicular to the axis of the prism as shown in the following figure. Assume that the incident wave has a wavelength much smaller than the dimension of the prism and the material parameters for the prism are: $\varepsilon_r = 3, \mu_r = 1$, and $\sigma = 0$. Please answer the following questions. (12%)



(a) Find the incident angle θ_i so as to produce a linearly polarized wave reflected from plane AB.

(b) Calculate the average power density for the reflected wave found in (a).

(c) What is the polarization state for the transmitted wave in the prism?

(d) Find the characteristic impedance for the absorption layer on plane BC so as to absorb the transmitted wave without producing reflection in the prism.

三、 An air-filled rectangular waveguide with cross-section dimension $a\times b=72\mathrm{mm}\times30\mathrm{mm}$ has been designed for transmitting Radar signal of 3GHz. (8%)

(a) What modes can propagate in this waveguide?

(b) Find the phase (β or propagation) constant.

(c) Determine the wave impedance.

(d) If the waveguide is made of brass which has a conductivity $\sigma=1.57\times10^{7}$ (S/m), find the attenuation constant due to loss in the guide walls.

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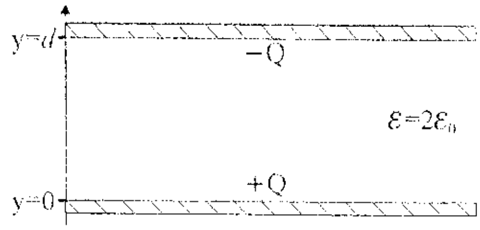
四、 Consider two conducting parallel plates of area S, separated by a distance d, and deposited with charges $\pm Q$, respectively.

(a) If $\{0<y<d\}$ is filled with a dielectric of permittivity $\varepsilon=2\varepsilon_0$, what are the electric flux density $\vec{D}$, and electric field intensity $\vec{E}$ inside the dielectric? (5%)



(A) $\vec{D}=-\vec{a}_y\dfrac{Q}{S},\ \vec{E}=-\vec{a}_y\dfrac{Q}{2\varepsilon_0 S}$;　(B) $\vec{D}=\vec{a}_y\dfrac{Q}{S},\ \vec{E}=\vec{a}_y\dfrac{Q}{2\varepsilon_0 S}$;　(C) $\vec{D}=\vec{a}_y\dfrac{2\varepsilon_0 Q}{S},\ \vec{E}=\vec{a}_y\dfrac{Q}{S}$;

(D) $\vec{D}=-\vec{a}_y\dfrac{2\varepsilon_0 Q}{S},\ \vec{E}=-\vec{a}_y\dfrac{Q}{S}$;　(E) $\vec{D}=\vec{a}_y\dfrac{2\varepsilon_0 S}{Q},\ \vec{E}=\vec{a}_y\dfrac{S}{Q}$;

(F) $\vec{D}=\vec{a}_y\dfrac{S}{Q},\ \vec{E}=\vec{a}_y\dfrac{S}{2\varepsilon_0 Q}$;　(G) $\vec{D}=-\vec{a}_y\dfrac{S}{Q},\ \vec{E}=-\vec{a}_y\dfrac{S}{2\varepsilon_0 Q}$;　(H) $\vec{D}=-\vec{a}_y\dfrac{2\varepsilon_0 S}{Q},\ \vec{E}=-\vec{a}_y\dfrac{S}{Q}$.

(b) According to (a), what are the polarization vector $\vec{P}$ inside the dielectric, and polarization surface charge density ρ_{ps} at $y=0$, $y=d$, respectively? (5%)

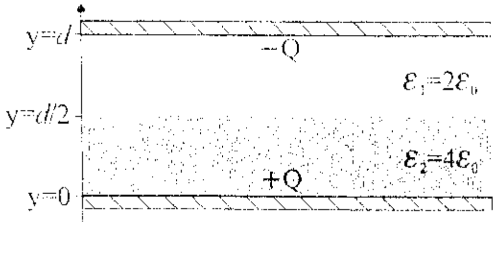
(A) $\vec{P}=\vec{a}_y\dfrac{Q}{S},\ \rho_{ps}(0)=\dfrac{Q}{2S},\ \rho_{ps}(d)=-\dfrac{Q}{2S}$;　(B) $\vec{P}=\vec{a}_y\dfrac{Q}{S},\ \rho_{ps}(0)=-\dfrac{Q}{2S},\ \rho_{ps}(d)=\dfrac{Q}{2S}$;

(C) $\vec{P}=-\vec{a}_y\dfrac{Q}{S},\ \rho_{ps}(0)=-\dfrac{Q}{2S},\ \rho_{ps}(d)=\dfrac{Q}{2S}$;　(D) $\vec{P}=-\vec{a}_y\dfrac{Q}{S},\ \rho_{ps}(0)=\dfrac{Q}{2S},\ \rho_{ps}(d)=-\dfrac{Q}{2S}$;

(E) $\vec{P}=\vec{a}_y\dfrac{Q}{2S},\ \rho_{ps}(0)=\dfrac{Q}{2S},\ \rho_{ps}(d)=-\dfrac{Q}{2S}$;　(F) $\vec{P}=\vec{a}_y\dfrac{Q}{2S},\ \rho_{ps}(0)=-\dfrac{Q}{2S},\ \rho_{ps}(d)=\dfrac{Q}{2S}$;

(G) $\vec{P}=-\vec{a}_y\dfrac{Q}{S},\ \rho_{ps}(0)=-\dfrac{Q}{2S},\ \rho_{ps}(d)=\dfrac{Q}{2S}$;　(H) $\vec{P}=-\vec{a}_y\dfrac{Q}{S},\ \rho_{ps}(0)=\dfrac{Q}{2S},\ \rho_{ps}(d)=\dfrac{Q}{2S}$.

(c) Let $\{d/2<y<d\}$ and $\{0<y<d/2\}$ are filled with dielectrics of permittivities $\varepsilon_1=2\varepsilon_0$ and $\varepsilon_2=4\varepsilon_0$, respectively. What is the polarization surface charge density ρ_{ps} at $y=\dfrac{d}{2}$? (5%)



(A) $\dfrac{Q}{2S}$; (B) $-\dfrac{Q}{2S}$; (C) $-\dfrac{Q}{4S}$; (D) $\dfrac{Q}{4S}$; (E) $\dfrac{Q}{S}$; (F) $-\dfrac{Q}{6S}$; (G) $-\dfrac{2Q}{3S}$; (H) $\dfrac{2Q}{3S}$.

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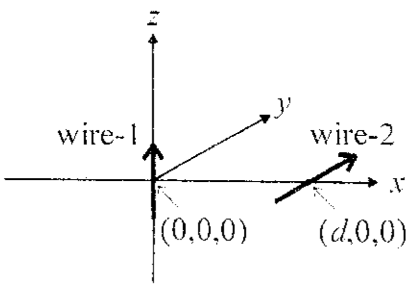
(d) According to (c), what is the polarization surface charge density ρ_{ps} at $y=\frac{d}{2}$ if medium-2 has non-vanishing conductivity ($\sigma_1=0$, $\sigma_2>0$)? (5%)

(A) $\frac{Q}{2S}$; (B) $-\frac{Q}{2S}$; (C) $-\frac{Q}{4S}$; (D) $\frac{Q}{4S}$; (E) $\frac{Q}{S}$; (F) $-\frac{Q}{6S}$; (G) $-\frac{2Q}{3S}$; (H) $\frac{2Q}{3S}$.

五、Consider two infinitely long conducting wires carrying steady current I along the $+z$ and $+y$ directions, respectively. If wire-1 is fixed, what will happen to wire-2? (5%)



(A) Rotate around x-axis;

(B) rotate around an axis passing through $(d,0,0)$ and in parallel with z-axis;

(C) move along the $+x$ direction;

(D) move along the $-x$ direction;

(E) move along the $+z$ direction;

(F) move along the $-z$ direction;

(G) move along the $+y$ direction;

(H) neither rotate nor move.

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六、 Suppose we have a superposition of two harmonic waves that have slightly different angular frequencies, i.e.

$$U = U_0 e^{i[(k+\Delta k)z-(\omega+\Delta\omega)t]} + U_0 e^{i[(k-\Delta k)z-(\omega-\Delta\omega)t]},$$

(a) Plot the combination of these two harmonic waves. (3%)

(b) Derive the phase velocity, $\mathbf{u}_p$, explain its physical meaning, and show it in your Plot. (4%)

(c) Derive the group velocity, $\mathbf{u}_g$, explain its physical meaning, and show it in your Plot. (4%)

In a medium in which the index of refraction, $n = c/\mathbf{u}_p$(where c is the speed of light in vacuum), varies in a known way with frequency or wavelength, show that with the wavelength λ, (4%)

$$u_g = u_p - \lambda \frac{du_p}{d\lambda}$$

七、 Select the correct answer. (5%)

If the refractive index is the same in object and image space, and a real object moves toward the optical system, then

(a) The image will move in the same direction for all magnifications and powers.

(b) The image will move in the opposite direction for all magnifications and powers.

(c) The image will move in the same direction for positive magnification and in the opposite direction for negative magnification.

(d) The image will move in the same direction for systems with positive power and in the opposite direction for systems with negative power.

(e) None of the above.

八、 Select the correct answer. (5%)

In order for the power of a system of two separated thin lenses to increase as the separation is increased,

(a) both lenses must be positive.

(b) both lenses must be negative.

(c) one of the lenses must be negative.

(d) the power of the initial system must be positive.

(e) none of the above.

九、 Light of wavelength 600nm in medium A of refractive index n_A=1.5 enters medium B of refractive index n_B=1.0. Make a sketch of reflectance vs. incident angle (from 0~90 degree) for p- and s-polarized incident lights. Mark the critical angle and Brewster's angle if there is any. (15%)