

類組：電機類 科目：電磁學(3007)

共 6 頁 第 1 頁

單選題，共二十題，每題5分。選擇題答案請填於答案卡，不倒扣。

1. Which of the following statements is true?
  - (A) Dynamic electromagnetic forces satisfy Newton's third law
  - (B) Static electromagnetic forces satisfy momentum conservation
  - (C) Given the electric field  $\mathbf{E} = -\nabla V - \frac{\partial}{\partial t} \mathbf{A}$  and charge  $q$ , the physical meaning of  $q\mathbf{A}$  is energy.
  - (D) All of the above are true
2. Which of the following cannot support TEM modes (ignoring the fringing effect):
  - (A) Two-wire line
  - (B) Rectangular waveguide
  - (C) Coaxial cable/line
  - (D) Microstrip line
3. Which of the following statements about the vector potential  $\mathbf{A}$  is *always* true?
  - (A)  $\nabla \times \mathbf{A} = \mathbf{B}$
  - (B)  $\nabla \cdot \mathbf{A} = 0$
  - (C)  $\nabla^2 \mathbf{A} = -\mu_0 \mathbf{J}$
  - (D) None of the above
4. There is a dielectric-filled parallel-planar metallic waveguide oriented in the way that guided waves propagate along  $z$  direction, and the separation  $d$  of two parallel is along  $y$  axis. Ignoring the fringing effect, the following field component of fundamental mode supported by the waveguide is non-zero:
  - (A)  $E_z$
  - (B)  $E_x$
  - (C)  $H_y$
  - (D)  $H_x$
5. In the complex notation (also called the phasor notation), we can express a monochromatic plane wave as  $\mathbf{E} = \mathbf{E}_0 e^{i(\mathbf{k} \cdot \mathbf{r} - \omega t)}$ . How do we calculate the time-averaged Poynting vector in this notation?
  - (A)  $\mathbf{E} \times \mathbf{H}$
  - (B)  $\text{Re}[\mathbf{E} \times \mathbf{H}]$
  - (C)  $\frac{1}{2} \text{Re}[\mathbf{E} \times \mathbf{H}^*]$
  - (D) None of the above

注意：背面有試題

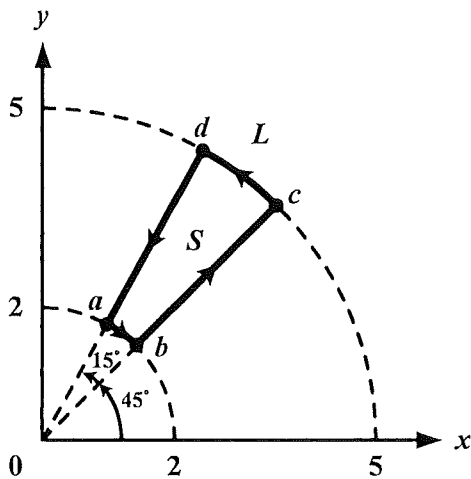
類組：電機類 科目：電磁學(3007)

共 6 頁 第 2 頁

6. Consider a plane wave traveling in a lossy material. The electric field is given by  $\mathbf{E} = \mathbf{E}_0 e^{i(kz - \omega t)}$ , where  $k$  equals  $1 + 0.1i$  ( $\mu\text{m}^{-1}$ ). The intensity of the plane wave can be expressed as  $I = I_0 e^{-\alpha z}$ , where  $\alpha$  is the absorption coefficient. Please calculate  $\alpha$ .

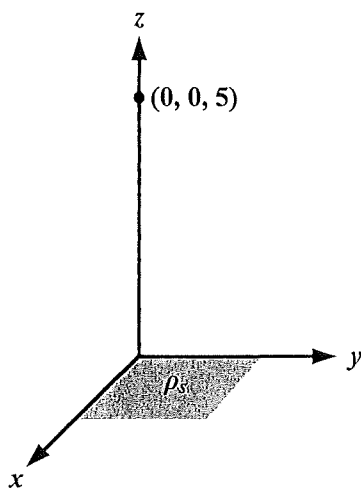
- (A)  $2$  ( $\mu\text{m}^{-1}$ )
- (B)  $0.2$  ( $\mu\text{m}^{-1}$ )
- (C)  $0.1$  ( $\mu\text{m}^{-1}$ )
- (D) None of the above

7. If  $\mathbf{A} = r \cos\phi \hat{\mathbf{r}} + \sin\phi \hat{\boldsymbol{\phi}}$ , evaluate  $\oint \mathbf{A} \cdot d\mathbf{l}$  around the path shown in the following figure.



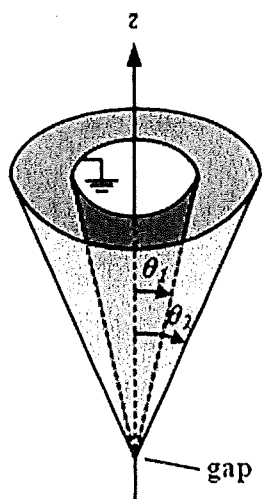
- (A) 0
- (B)  $\frac{27}{4}(\sqrt{2} + 1)$
- (C)  $\frac{27}{4}(\sqrt{2} - 1)$
- (D) None of the above

8. The finite sheet  $0 \leq x \leq 1$  and  $0 \leq y \leq 1$  on the  $z = 0$  plane has a surface charge density  $\rho_s = xy(x^2 + y^2 + 25)^{3/2}$  nC/m<sup>2</sup>. Evaluate the electric field at  $(0, 0, 5)$ .



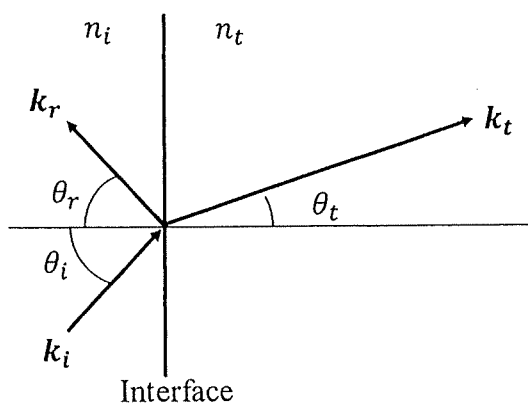
- (A)  $-3\hat{\mathbf{x}} - 3\hat{\mathbf{y}} + 22.5\hat{\mathbf{z}}$  V/m
- (B)  $-3\hat{\mathbf{x}} - 3\hat{\mathbf{y}} + 11.25\hat{\mathbf{z}}$  V/m
- (C)  $-1.5\hat{\mathbf{x}} - 1.5\hat{\mathbf{y}} + 22.5\hat{\mathbf{z}}$  V/m
- (D)  $-1.5\hat{\mathbf{x}} - 1.5\hat{\mathbf{y}} + 11.25\hat{\mathbf{z}}$  V/m

9. In the following figure, two conducting cones of infinite extent with  $\theta_1$  and  $\theta_2$  are separated by an infinitesimal gap at  $R = 0$ . If  $0 < \theta_1 < \theta_2 < \frac{\pi}{2}$ ,  $V(\theta_1) = 0$ , and  $V(\theta_2) = 10$  V, evaluate the potential distribution  $V(\theta)$  between the cones.



- (A)  $10 \left[ \ln \left( \tan \frac{\theta}{2} \cot \frac{\theta_1}{2} \right) \right] / \left[ \ln \left( \tan \frac{\theta_2}{2} \cot \frac{\theta_1}{2} \right) \right] \text{ V}$   
 (B)  $10 \left[ \ln \left( \tan \frac{\theta}{4} \cot \frac{\theta_1}{4} \right) \right] / \left[ \ln \left( \tan \frac{\theta_2}{4} \cot \frac{\theta_1}{4} \right) \right] \text{ V}$   
 (C)  $10 \left[ \ln(\tan \theta \cot \theta_1) \right] / \left[ \ln(\tan \theta_2 \cot \theta_1) \right] \text{ V}$   
 (D)  $10 \left[ \ln(\tan 2\theta \cot 2\theta_1) \right] / \left[ \ln(\tan 2\theta_2 \cot 2\theta_1) \right] \text{ V}$

10. Consider a plane wave that is incident obliquely on an interface between two dielectric media of refractive indices of  $n_i$  and  $n_t$ , as shown in the figure. We express the incident wave and transmitted wave as  $\mathbf{E}_i = \mathbf{E}_{0i} e^{i(\mathbf{k}_i \cdot \mathbf{r} - \omega t)}$  and  $\mathbf{E}_t = \mathbf{E}_{0t} e^{i(\mathbf{k}_t \cdot \mathbf{r} - \omega t)}$ , respectively. Here,  $\mathbf{k}_i$ ,  $\mathbf{k}_r$ , and  $\mathbf{k}_t$  are the wave vectors of the incident wave, reflected wave, and transmitted wave, respectively. These wave vectors are all on the same plane. Which one of the following relations is correct?

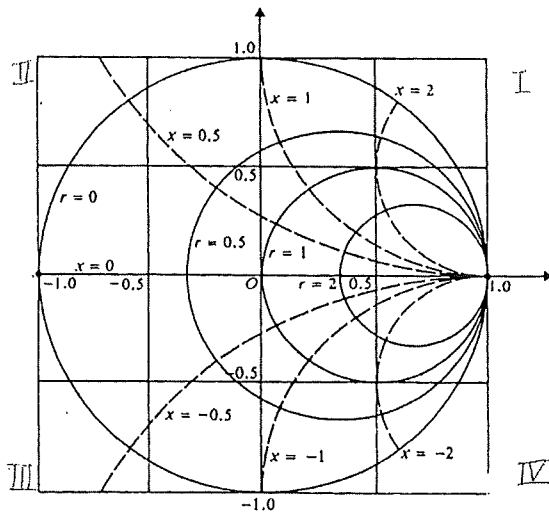


- (A)  $k_i \cos \theta_i = k_t \cos \theta_t$   
 (B)  $k_i \sin \theta_i = k_t \sin \theta_t$   
 (C)  $k_i n_i \sin \theta_i = k_t n_t \sin \theta_t$   
 (D) None of the above

類組：電機類 科目：電磁學(3007)

共 6 頁 第 4 頁

11. Consider an ideal lossless transmission line with the characteristic impedance  $R_0 = 50 \Omega$ . The transmission line is connected to a load which is composed of a resistor  $R = 25 \Omega$  and a capacitor  $C = 0.2 \text{ pF}$  in series. The signal frequency is at 10 GHz. If we want to use the Smith chart for determining the signal reflectivity at the load interface, please refer to the following figure and determine inside which quadrant (象限) of the Smith chart the data point will be located:



- (A) I  
(B) II  
(C) III  
(D) IV

12. A TE wave propagating in a dielectric-filled rectangular metallic waveguide of unknown permittivity has dimension  $a = 5 \text{ cm}$  and  $b = 2 \text{ cm}$ . If the  $x$  component of its electric field is given by

$$E_x = -10 \cos(40\pi x) \sin(100\pi y) \sin(2.4\pi \times 10^{10} t - 52.9\pi z) \text{ (V/m)}$$

Which following statement is correct:

- (A) The mode number is  $\text{TE}_{23}$   
 (B)  $\epsilon_r$  of the filled dielectric material is 2  
 (C) The cutoff frequency of the TE mode is below 11 GHz  
 (D) None of the above
13. The quality factor  $Q$  for a hollow resonant cavity operating in the  $\text{TE}_{101}$  mode is about 6000, and the frequency of the  $\text{TE}_{101}$  mode is 15 GHz. What is the bandwidth of the cavity at the  $\text{TE}_{101}$  mode?
- (A) 2.50 MHz  
 (B) 1.67 MHz  
 (C) 1.33 MHz  
 (D) None of the above

類組：電機類 科目：電磁學(3007)

共 6 頁 第 5 頁

14. A disk of a surface charge density  $\sigma_0$  and a radius  $a$  is on the  $x$ - $y$  plane and spinning about its center with an angular velocity  $\boldsymbol{\omega} = \omega_0 \hat{\mathbf{z}}$ . What is the  $\mathbf{B}$  at its center?
- (A) 0
- (B)  $\frac{\mu_0 \sigma_0 \omega_0 a}{4} \hat{\mathbf{z}}$
- (C)  $\frac{\mu_0 \sigma_0 \omega_0 a}{3} \hat{\mathbf{z}}$
- (D) None of the above
15. A wire is defined by the parametric equations:  $x = a \cos u$ ,  $y = a \sin u$ , and  $z = a \sin u$  for  $u$  in  $[0, 2\pi]$ . A current  $I$  flows counterclockwise on the wire (top view, from  $+z$  to  $-z$ ). What is the magnetic dipole moment of the wire?
- (A)  $I\pi a^2 \hat{\mathbf{x}} + I\pi a^2 \hat{\mathbf{z}}$
- (B)  $-I\pi a^2 \hat{\mathbf{y}} + I\pi a^2 \hat{\mathbf{z}}$
- (C)  $I\pi a^2 \hat{\mathbf{y}} + I\pi a^2 \hat{\mathbf{z}}$
- (D) None of the above
16. A DC voltage source is connected across a long, straight conducting wire with radius  $a$  and conductivity  $\sigma$  carries a direct current  $I$  along the  $-z$  direction. Determine the Poynting vector on the surface of the wire associated with the electromagnetic fields.
- (A)  $-\frac{I^2}{\sigma \pi^2 a^3} \hat{\mathbf{r}}$
- (B)  $-\frac{I^2}{2\sigma \pi^2 a^3} \hat{\mathbf{r}}$
- (C)  $\frac{I^2}{\sigma \pi^2 a^3} \hat{\mathbf{r}}$
- (D)  $\frac{I^2}{2\sigma \pi^2 a^3} \hat{\mathbf{r}}$
17. An AC voltage source  $V_0 \sin(\omega t)$  (V) is connected across a parallel-plate capacitor  $C$ . The capacitor has circular plates with a radius  $a$ . Determine the  $\mathbf{H}$  at a distance  $r$  from the axis of the capacitor, where  $r < a$ .
- (A)  $\frac{CV_0\omega}{\pi a} \cos(\omega t) \hat{\boldsymbol{\phi}}$  (A/m)
- (B)  $\frac{CV_0\omega}{2\pi a} \cos(\omega t) \hat{\boldsymbol{\phi}}$  (A/m)
- (C)  $\frac{CV_0\omega}{\pi r} \cos(\omega t) \hat{\boldsymbol{\phi}}$  (A/m)
- (D)  $\frac{CV_0\omega}{2\pi r} \cos(\omega t) \hat{\boldsymbol{\phi}}$  (A/m)

注意：背面有試題

18. Consider an ideal lossless coaxial cable transmission line. The dielectric material between the two conductors of the coaxial cable is with a dielectric constant  $\epsilon = 2.25 \epsilon_0$ . The cable is open-circuited at one end and is excited with a sinusoidal signal at 1 GHz from the other end. We want to determine at which position inside the cable, the root-mean-square (rms) of the net voltage will have the minimum value. If the distance between the nearest minimum rms voltage point and the open-circuited end is  $L$ , please determine which is the closest value for  $L$  among the following choices:
- (A) 4 cm
  - (B) 5 cm
  - (C) 6 cm
  - (D) 7 cm
19. Consider an ideal lossless transmission line with the characteristic impedance  $R_0 = 100 \Omega$ . A  $\lambda/8$  section ( $\beta \cdot l = \pi/4$ ) of this transmission line is connected to a load with an impedance  $Z_L$  and the input impedance seen from the input end of the  $\lambda/8$  ( $\beta \cdot l = \pi/4$ ) transmission line with the load is exactly  $Z_i = 50 \Omega$ . Please determine which is the nearest value for the real part of the load impedance,  $\text{Re}[Z_L]$ , among the following choices:
- (A)  $50 \Omega$
  - (B)  $60 \Omega$
  - (C)  $70 \Omega$
  - (D)  $80 \Omega$
20. Consider a lossy distortionless transmission line. The characteristic impedance is  $50 \Omega$ , the phase velocity is  $2 \times 10^8$  m/s, and the operation frequency is 1 GHz. For the four transmission line parameters  $R$ ,  $L$ ,  $G$ ,  $C$  of the distortionless transmission line, if we already know the value of  $R$  is  $0.1 \Omega/\text{m}$  and the signal voltage propagates in the  $z$  direction as  $V(z) = V(0)\exp(-\alpha z - j\beta z)$  without the reflected signal, please determine which is the nearest value for the ratio  $\beta/\alpha$  among the following choices:
- (A)  $10^3$
  - (B)  $10^4$
  - (C)  $10^5$
  - (D)  $10^6$