以下均為單選題，請將答案寫在電腦閱卷答案卡上

1. Which of the following statements is not correct?
(A) $\nabla r = \hat{r}$ (B) $\nabla \times \frac{\hat{r}}{r^2} = 0$ (C) $\nabla \cdot \frac{\hat{r}}{r^2} = 0$ (D) $\nabla^2 r = \frac{2}{r}$

2. Which of the following statements is not correct?
(A) A curl-less vector field can be expressed as the gradient of a scalar field.
(B) A divergence-less vector field can be expressed as the curl of a vector field.
(C) A curl-less and divergence-less vector field is a constant vector field.
(D) A smooth and rapidly decaying vector field can be expressed as the sum of a curl-less vector field and a divergence-less vector field.

3. A charged particle at rest is released in a region of uniform electric field in the y direction and uniform magnetic field in the z direction. Which of the following statements is not correct?
(A) The motion of the particle in the y direction is periodic.
(B) In average, the particle moves with a constant speed in the x direction.
(C) The kinetic energy of the particle increases with time.
(D) The magnetic field does no work on the particle.

4. For an ideal electric quadruple, what is the relation between the electric field strength E and the distance r in the far field?
(A) $E \propto r^{-1}$ (B) $E \propto r^{-2}$ (C) $E \propto r^{-3}$ (D) $E \propto r^{-4}$

5. Consider two long parallel wires of radius a, separated by a distance d. If d □ a, find the capacitance per unit length.
(A) $\frac{\varepsilon_0 \pi}{\ln d - \ln a}$ (B) $\frac{2\varepsilon_0 \pi}{\ln d - \ln a}$ (C) $\frac{\varepsilon_0 \pi}{\ln d + \ln a}$ (D) $\frac{2\varepsilon_0 \pi}{\ln d + \ln a}$

6. In the static case, consider an interface between the free space and a perfect conductor with some charges on the surface. Which of the following statements is not correct?
(A) The electric field in the free space near the surface is proportional to the surface charge density.
(B) There is no electric field in the conductor.
(C) The surface charge would experience no electric force.
(D) The electric potential is the same in the conductor, even near sharp edges.

7. An uncharged metal sphere is placed in an otherwise uniform electric field $E_0\hat{z}$. Find the induced surface charge density.
(A) Zero everywhere on the sphere. (B) $\varepsilon_0 E_0 \cos\theta$ (C) $2\varepsilon_0 E_0 \cos\theta$ (D) $3\varepsilon_0 E_0 \cos\theta$

8. What does ρ in the Gauss's law $\nabla \cdot \bar{D} = \rho$ mean?
(A) The free volume charge density.
(B) The free surface charge density.
(C) The sum of the polarization volume charge density and the free volume charge density.
(D) The sum of all surface charge density and volume charge density.

9. What does $\bar{J}$ in the Ampere's law $\nabla \times \bar{H} = \bar{J} + \frac{\partial \bar{D}}{\partial t}$ mean?
(A) The free volume current density.
(B) The free surface current density.
(C) The sum of the polarization current density, the magnetization current density, and the free current density.
(D) The sum of all surface current density and volume current density.

10. Consider a uniformly polarized dielectric sphere where the polarization inside the sphere is $\bar{P}$. Find the displacement field $\bar{D}$ inside the sphere.
(A) 0 (B) $\frac{2}{3}\bar{P}$ (C) $-\frac{1}{3}\bar{P}$ (D) $\bar{P}$

11. A short solenoid (length l, radius a, n_1 turns per unit length) lies on the axis of a very one solenoid (length l, radius b, n_2 turns per unit length), where $a<b$. What is the total magnetic flux through the long solenoid if a steady current I flows in the short

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solenoid?

(A) $\mu_0\pi a^2 n_1 n_2 lI$ (B) $\mu_0\pi b^2 n_1 n_2 lI$ (C) $\mu_0\pi a^2 n_1^2 lI$ (D) $\mu_0\pi ab n_1 n_2 lI$

12. Which of the following statements is not correct in general?
(A) Diamagnetism could be related to the orbital motion of electrons.
(B) Paramagnetism could be related to the electronic spin.
(C) Ferromagnetism becomes obvious above the Curie temperature.
(D) Antiferromagnetism vanishes above the Neel temperature.

13. Consider a sheet current source $-J_{S0}\cos(\omega t)\hat{x}$ at $z=0$. The medium on either side of the sheet is free space. Which of the following statements for the region $z>0$ is not correct?
(A) There will be a wave propagating in the +z direction.
(B) The electric field and magnetic field are in phase.
(C) The instantaneous power flow out of an arbitrary closed surface is zero.
(D) The average power flow is half of the peak power flow.

14. Consider a sheet current source $-J_{S0}\cos(\omega t)\hat{x}$ at $z=0$. The medium on either side of the sheet is perfect dielectric. Assume the dielectric constant is higher in the $z>0$ region. Which of the following statements is not correct?
(A) The power flux is higher in the $z>0$ region.
(B) The power flux is higher in the $z<0$ region.
(C) The power flux is the same in both regions
(D) There is no power flux in both regions.

15. Assume the relation $\bar{D}=\varepsilon\bar{E}$ holds in a medium, where ε is a constant. What do we not imply for that medium?
(A) The medium is linear.
(B) The medium is isotropic.
(C) The medium is nondispersive.
(D) The medium is lossless.

16. Assume two electromagnetic waves (frequency f_A and f_B) enters a nonlinear material whose polarization field includes a term that is proportional to the square of the electric field. Which of the following frequencies could one possibly observe at the output of the nonlinear material?
(A) f_A+f_B (B) $2f_A$ (C) $2f_B$ (D) All of the above.

17. Consider a situation that region 1 ($z<0$) is free space and region 2 ($z>0$) is an anisotropic lossless nonmagnetic material described by the following relationship.

$$\begin{bmatrix} D_x \\ D_y \\ D_z \end{bmatrix} = \varepsilon_0 \begin{bmatrix} 3 & -1 & 0 \\ -1 & 3 & 0 \\ 0 & 0 & 6 \end{bmatrix} \begin{bmatrix} E_x \\ E_y \\ E_z \end{bmatrix}$$

For a uniform plane wave with the electric field $E_0\cos\left[\omega(t-\sqrt{\varepsilon_0\mu_0}z)\right]\hat{x}$ incident on the interface $z=0$ form region 1. What is the electric field of the reflected wave?

(A) $E_0\cos\left[\omega(t+\sqrt{\varepsilon_0\mu_0}z)\right]\left(\dfrac{1-\sqrt{3}}{1+\sqrt{3}}\hat{x}\right)$

(B) $E_0\cos\left[\omega(t+\sqrt{\varepsilon_0\mu_0}z)\right]\left(\dfrac{2\sqrt{2}-3}{2}\hat{x}+\dfrac{2\sqrt{2}-5}{2}\hat{y}\right)$

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(C) $E_0\cos\left[\omega(t+\sqrt{\varepsilon_0\mu_0}z)\right]\left(\frac{3\sqrt{2}-5}{3}\hat{x}+\frac{3\sqrt{2}-4}{3}\hat{y}\right)$

(D) None of the above.

18. Following the previous question, what is the electric field of the transmitted wave?

(A) $E_0\cos\left[\omega(t+\sqrt{3\varepsilon_0\mu_0}z)\right]\left(\frac{2}{1+\sqrt{3}}\hat{x}\right)$

(B) $(\sqrt{2}-1)(\hat{x}+\hat{y})E_0\cos\left[\omega(t-\sqrt{2\varepsilon_0\mu_0}z)\right]+\frac{1}{3}(\hat{x}-\hat{y})E_0\cos\left[\omega(t-2\sqrt{\varepsilon_0\mu_0}z)\right]$

(C) $E_0\cos\left[\omega(t-\sqrt{2\varepsilon_0\mu_0}z)\right]\left[\left(\sqrt{2}-\frac{2}{3}\right)\hat{x}+\left(\sqrt{2}-\frac{4}{3}\right)\hat{y}\right]$

(D) None of the above.

19. A randomly polarized electromagnetic wave in free space is incident on a lossless medium with a dielectric constant of 3. At what incident angle does the reflected wave become linearly polarized?

(A) 0 degree (B) 30 degrees (C) 60 degrees (D) None

20. Assume the electron density is $10^6\ \text{cm}^{-3}$ in a certain layer of ionsphere. Which of the following frequency of electromagnetic waves that could pass through that layer?

(A) 12 MHz (B) 8 MHz (C) 4 MHz (D) 1 MHz

21. If $\bar{E}(z,t)=\hat{y}9\cos(6\pi\times10^7t-\frac{1}{5}\pi z)$ V/m. Find $\bar{H}(z,t)$.

(A) $\bar{H}(z,t)=-\hat{x}90\cos(6\pi\times10^7t-\frac{1}{5}\pi z)$ mA/m

(B) $\bar{H}(z,t)=\hat{x}50\cos(6\pi\times10^7t-\frac{1}{5}\pi z)$ mA/m

(C) $\bar{H}(z,t)=-\hat{x}24\cos(6\pi\times10^7t-\frac{1}{5}\pi z)$ mA/m

(D) $\bar{H}(z,t)=-\hat{x}44\cos(6\pi\times10^7t-\frac{1}{5}\pi z)$ mA/m

22. In an air-filled parallel-plate waveguide with dimension $a=4$ cm, according to the expression of electric field distribution,

$$E=E_0(\sin25\pi x+3\sin50\pi x)\sin(8\times10^9\pi t)$$

What is the value of phase constant β_z of propagation wave?

(A) 7.5 (B) 23.5 (C) 29.2 (D) 74 rad/m

23. Consider a parallel-plate waveguide (plates at *y=0* and *y=b* planes), with wave propagating in the $+z$ direction. For the lowest-order TM mode, if the instantaneous field expression for the z-component of the electric field at $(x, y, z) = (x, b/4, 0)$ is $E_z(t)=E_0\cos wt$, what is the corresponding expression for $E_z(t)$ at $(x, y, z) = (x, b/2, d)$?

(A) $2E_0\cos(wt-\beta d)$ (B) $\sqrt{2}E_0\cos(wt-\beta d)$ (C) $2E_0\sin(wt-\beta d)$ (D) $\sqrt{2}E_0\sin(wt-\beta d)$

24. Find the spacing *d* for a parallel-plate waveguide having a dielectric of $\varepsilon=4\varepsilon_0$ and $\mu=\mu_0$ such that 5 GHz is the cutoff frequency of the dominant mode.

(A) 1 (B) 1.5 (C) 2 (D) 2.5 cm

25. A wave in air is incident upon a soil surface at $\theta_i=40°$. If soil has $\varepsilon_r=2.2$ and $\mu_r=1$, determine $\Gamma_\perp$ and $\tau_\perp$.

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(A) $\Gamma_{\perp}=-0.48, \tau_{\perp}=0.52$ (B) $\Gamma_{\perp}=-0.27, \tau_{\perp}=0.52$ (C) $\Gamma_{\perp}=-0.27, \tau_{\perp}=0.73$ (D) $\Gamma_{\perp}=-0.48, \tau_{\perp}=0.73$

26. The magnetic field in a given dielectric medium is given by $\overline{H}=y6\cos(2z)\sin(2\times10^{7}t-0.1x)$ $(\mathrm{A/m})$, where x and z are in meters. Determine the phase velocity of the electromagnetic wave.

(A) 2×10^{8} (m/s)

(B) 3×10^{8} (m/s)

(C) 5×10^{8} (m/s)

(D) 1.5×10^{8} (m/s)

27. The magnetic field associated with a uniform plane wave propagating in the +z-direction in free space is given by $\overline{H}=H_0\cos(6\pi\times10^{7}t-0.2\pi z)y$ (A/m). Find the instantaneous power flow across a surface of area $1\mathrm{m}^2$ in the z=0 plane at t=(1/8) μ s.

(A)0 W (B)1 W (C)1.5 W (D)3 W

28. The electric field of a plane wave is given by $\overline{\mathrm{E}}(\mathrm{z,t}) = x\,3\cos(\omega\mathrm{t}-\mathrm{kz}) + y\,4\cos(\omega\mathrm{t}-\mathrm{kz})$ $(\mathrm{V/m})$. Determine the polarization state of the corresponding electromagnetic wave.

(A) Linear Polarization
(B) Right-Hand Circular Polarization
(C) Left-Hand Circular Polarization
(D) Elliptical Polarization

29. The general expression of the voltage on a lossless transmission line in the sinusoidal steady state is

$$V(z,t) = A\cos\left[\omega\left(t-\frac{z}{v_p}\right)+\theta\right]+B\cos\left[\omega\left(t+\frac{z}{v_p}\right)+\phi\right].$$

Which one of the following statements is wrong?

(A) The current can be expressed as

$$I(z,t) = \frac{1}{Z_0}\left\{A\cos\left[\omega\left(t-\frac{z}{v_p}\right)+\theta\right]+B\cos\left[\omega\left(t+\frac{z}{v_p}\right)+\phi\right]\right\}$$

, where Z_0 is the characteristic impedance of the transmission line.

(B) If B is zero, there is no standing wave on the transmission line.
(C) The first term and the second term represent the waves going in the $+z$ and $-z$ directions, respectively.
(D) ω/v_p is the propagation constant.

30. A 50-Ω transmission line is terminated by a load. Which one of the following statements is wrong?

(A) If the load impedance is 0Ω and the electrical length of the transmission line is 90 degree, the input impedance is ∞.
(B) If the load impedance is 100Ω and the electrical length of the transmission line is 90 degree, the input impedance is 20Ω.
(C) If the load impedance is 200Ω and the electrical length of the transmission line is 180 degree, the input impedance is 200Ω.
(D) If the load impedance is 30Ω and the electrical length of the transmission line is 360 degree, the input impedance is 30Ω.

31. For the system impedance of Z_0, what is the component which can match the impedance at point A to point B along the constant VSWR circle as shown in Fig. 1?

(A) A series capacitor.

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(B) A series resistor.

(C) A series transmission line with characteristic impedance of Z_0.

(D) A shunt short-circuited transmission line with characteristic impedance of Z_0.

32. Which one cannot allow TEM wave propagation?

(A) Rectangular metal waveguide.

(B) Coaxial cable.

(C) Parallel-plate waveguide.

(D) Stripline.

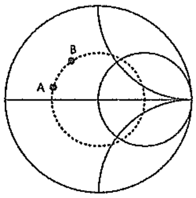

Fig. 1

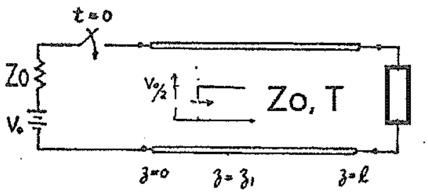

Fig. 2

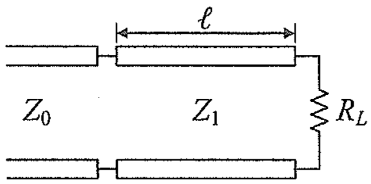

Fig. 3

For Probs. 33-36, consider a step pulse incident to a transmission line with terminating load, as shown in Fig. 2.

33. If the load is a pure inductor L, which statement is WRONG?

(A) A reflected wave is resulted since the boundary condition at load is violated.

(B) The inductor is initially open, hence the voltage at the load will be Vo at $t=T^+$.

(C) The reflected wave will be of positive voltage for t > T.

(D) The voltage at the load will be zero as t tends to infinity.

34. If the load is a series resistor R = Zo and inductor L, which statement is WRONG?

(A) The current at the load should be continuous versus t, due to the presence of L.

(B) The inductor is initially open, hence the voltage at the load will be Vo at $t=T^+$.

(C) The reflected wave will be of positive voltage for t > T.

(D) The voltage at the load will be zero as t tends to infinity.

35. If the load is a pure capacitor C, which statement is WRONG?

(A) The voltage at the load should be continuous versus t, due to the presence of C.

(B) The capacitor is initially short, hence the voltage at the load will be 0 at $t=T^+$.

(C) The reflected wave will be of positive voltage for t much larger than T.

(D) The voltage at the load will be zero as t tends to infinity.

36. If the load is a shunt connection of capacitor C and resistor R = Zo, which statement is WRONG?

(A) The voltage at the load should be continuous versus t, due to the presence of C.

(B) The capacitor is initially short, hence the voltage at the load will be zero at t=T.

(C) The reflected wave will be of positive voltage for t much larger than T.

(D) The voltage at the load will be Vo/2 as t tends to infinity.

37. Design a transmission line of characteristic impedance Z_0 and length ℓ, as shown in the Fig. 3, to match a resistive load $R_L = 300$ Ω to a lossless transmission line of characteristic impedance $Z_0 = 75$ Ω

(A) $Z_1 = 150\Omega, \ell = \lambda/8$

(B) $Z_1 = 187.5\Omega, \ell = \lambda/8$

(C) $Z_1 = 150\Omega, \ell = \lambda/4$

(D) $Z_1 = 187.5\Omega, \ell = \lambda/4$

(E) $Z_1 = 150\Omega, \ell = \lambda/2$

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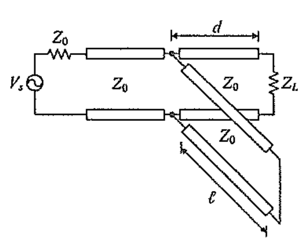


Fig. 4

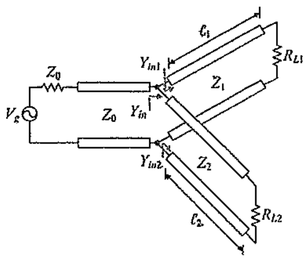


Fig. 5

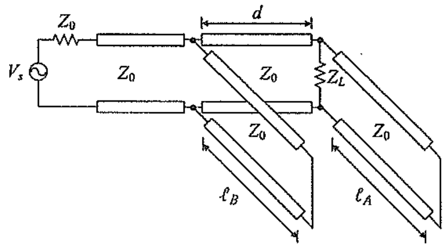
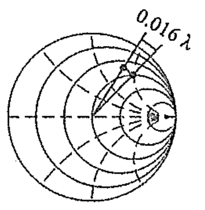
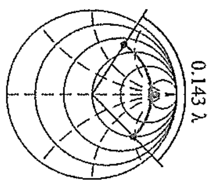


Fig. 6

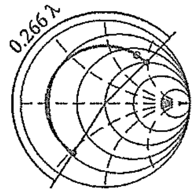
38. A 50-Ω transmission line is connected to a load of impedance $Z_L = 35 + j80\Omega$. Find the position d and length ℓ of a short-circuited stub required for impedance matching, as shown in the Fig. 4.



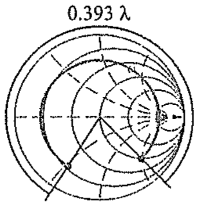
(A) $d = 0.016\lambda$, $\ell = 0.076\lambda$



(B) $d = 0.143\lambda$, $\ell = 0.174\lambda$



(C) $d = 0.266\lambda$, $\ell = 0.076\lambda$;



(D) $d = 0.393\lambda$, $\ell = 0.174\lambda$

(E) It is impossible to match the load using the single-stub matching circuit.

39. Figure 5 shows a power divider of power ratio $P_{L1}/P_{L2} = 1$, where P_{L1} and P_{L2} are the power delivered to the loads R_{L1} and R_{L2}, respectively. The loads have resistance $R_{L1} = 75\Omega$ and $R_{L2} = 300\Omega$, and the characteristic impedance of the transmission line is $Z_0 = 50\Omega$. Find the characteristic impedances Z_1 and Z_2 of the quarter-wavelength transmission lines ($\ell_1 = \ell_1 = \lambda/4$) so that the impedance is matched from the source.

(A) $Z_1 = 61.2\Omega$, $Z_2 = 122.5\Omega$;

(B) $Z_1 = 122.5\Omega$, $Z_2 = 61.2\Omega$;

(C) $Z_1 = 86.6\Omega$, $Z_2 = 173.2\Omega$;

(D) $Z_1 = 173.2\Omega$, $Z_2 = 86.6\Omega$;

(E) It is impossible to match the loads by using the quarter-wavelength transformers.

40. A 50-Ω transmission line is connected to a load of impedance $Z_L = 35 + j80\Omega$. Design a double-stub matching circuit shown in the Fig. 6. Short-circuited stubs are used and the position of the second stub is $d = \lambda/8$.

(A) $\ell_A = 0.365\lambda$, $\ell_B = 0.209\lambda$;　　(B) $\ell_A = 0.365\lambda$, $\ell_B = 0.082\lambda$;

(C) $\ell_A = 0.181\lambda$, $\ell_B = 0.209\lambda$;　　(D) $\ell_A = 0.115\lambda$, $\ell_B = 0.332\lambda$;

(E) It is impossible to match the load using the double-stub matching circuit.

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