Test 7.1: TEM Wave

A TEM wave propagating from an aircraft overhead towards the ground has its **E** field pointing eastward. What is the direction of its **H** field?

(a) **H** points westward.
(b) **H** points northward.
(c) **H** points southward.
(d) **H** points eastward.

Test 7.2: Wavelength

The electric field of a plane wave propagating in a nonmagnetic material is given by

$$\mathbf{E} = [\hat{\mathbf{y}}\, 3\sin(\pi \times 10^8 t - \pi x) + \hat{\mathbf{z}}\, 4\cos(\pi \times 10^8 t - \pi x)] \qquad \text{(V/m)}.$$

Determine the wavelength λ.

(a) $\lambda = 10$ m
(b) $\lambda = 2$ m
(c) $\lambda = 0.2$ m
(d) $\lambda = 0.1$ m

Test 7.3: Relative Permittivity

The electric field of a plane wave propagating in a nonmagnetic material is given by

$$\mathbf{E} = [\hat{\mathbf{y}}\, 3\sin(\pi \times 10^8 t - \pi x) + \hat{\mathbf{z}}\, 4\cos(\pi \times 10^8 t - \pi x)] \qquad \text{(V/m)}.$$

Determine the relative permittivity of the material.

(a) $\varepsilon_r = 4$
(b) $\varepsilon_r = 1$
(c) $\varepsilon_r = 36$
(d) $\varepsilon_r = 9$

Test 7.4: Wavelength

The electric field of a plane wave propagating in a lossless, nonmagnetic, dielectric material with $\varepsilon_r = 2.56$ is given by

$$\mathbf{E} = \hat{\mathbf{y}}\, 12\cos(6\pi \times 10^9 t - kz) \qquad \text{(V/m)}.$$

Determine the wavelength λ in the material.

(a) $\lambda = 6.24$ cm
(b) $\lambda = 2$ m
(c) $\lambda = 8.4$ cm
(d) $\lambda = 62.4$ cm

Test 7.5: Intrinsic Impedance

The electric field of a plane wave propagating in a lossless, nonmagnetic, dielectric material with $\varepsilon_r = 14.2$ is given by

$$\mathbf{E} = \hat{\mathbf{y}}\, 12 \cos(6\pi \times 10^9 t - kz) \qquad \text{(V/m)}.$$

Determine the intrinsic impedance η of the material.

(a) $\eta = 187\ \Omega$
(b) $\eta = 76\ \Omega$
(c) $\eta = 100\ \Omega$
(d) $\eta = 63\ \Omega$

Test 7.6: RFID

RFID tags operating at the microwave frequency of 2.45 GHz offer superior performance over those operating at lower frequencies in the following regard:

(a) Greater read range and lower power requirements.
(b) Greater read range and higher data rate.
(c) Higher data rate and lower power requirements.
(d) Smaller size and lower power requirements.

Test 7.7: Wave Polarization

A helical antenna is used to generate:

(a) Linearly polarized EM waves.
(b) Elliptically polarized EM waves.
(c) Circularly polarized EM waves.
(d) More of the above.

Test 7.8: RHC Polarization

A TEM wave is right-hand circularly polarized if the **E** vector:

(a) rotates counterclockwise as it travels in space.
(b) rotates clockwise as a function of time when viewed in a plane across the direction of travel.
(c) rotates at the same rate as the **H** vector.
(d) rotates counterclockwise as a function of time when viewed in a plane across the direction of travel.

Test 7.9: Linear Polarization

The electric field of a plane wave is given by:

$$\mathbf{E}(z,t) = \hat{\mathbf{x}} a_x \cos(\omega t - kz) + \hat{\mathbf{y}} a_y \cos(\omega t - kz + \delta).$$

The wave is linearly polarized only if:

(a) $\delta = 0$ or π
(b) $a_x = a_y$
(c) $a_x = 0$ or $a_y = 0$
(d) $a_x = a_y$ and $\delta = 0$

Test 7.10: RHC Polarization

The electric field of a plane wave is given by:

$$\mathbf{E}(z,t) = \hat{\mathbf{x}} a_x \cos(\omega t - kz) + \hat{\mathbf{y}} a_y \cos(\omega t - kz + \delta).$$

The wave is RHC polarized only if:

(a) $\delta = 0$
(b) $a_x = a_y$
(c) $a_x = a_y$ and $\delta = \pi/2$
(d) $a_x = a_y$ and $\delta = -\pi/2$

Test 7.11: Good Conductor

Seawater has a relative permittivity $\varepsilon_r = 80$ and a conductivity $\sigma = 4$ (S/m). Over what frequency range does seawater behave like a good conductor?

(a) $f < 9$ MHz
(b) $f > 180$ MHz
(c) $f < 18$ kHz
(d) $f > 2$ GHz

Test 7.12: Good Conductor

Dry soil has a relative permittivity $\varepsilon_r = 2.5$ and a conductivity $\sigma = 10^{-4}$ (S/m). Over what frequency range does dry soil behave like a good conductor?

(a) $f > 1$ MHz
(b) $f < 700$ kHz
(c) $f < 1$ kHz
(d) $f > 1$ GHz

Test 7.13: Skin Depth

Seawater has a relative permittivity $\varepsilon_r = 80$, magnetic permeability $\mu = \mu_0$, and a conductivity $\sigma = 4$ (S/m). What is the skin depth of seawater at 1 MHz?

(a) $\delta_s = 100$ m
(b) $\delta_s = 1$ cm
(c) $\delta_s = 1$ km
(d) $\delta_s = 25$ cm

Test 7.14: Power Density

A wave traveling in a nonmagnetic medium with $\varepsilon_r = 9$ is characterized by an electric field given by

$$\mathbf{E} = [\hat{\mathbf{y}}\, 6\cos(\pi \times 10^7 t + kx) - \hat{\mathbf{z}}\, 4\cos(\pi \times 10^7 t + kx)] \qquad \text{(V/m)}.$$

What is the average power density carried by the wave?

(a) $S_{av} = 12$ (W/m^2)
(b) $S_{av} = 0.2$ (W/m^2)
(c) $S_{av} = 8$ (mW/m^2)
(d) $S_{av} = 2$ (mW/m^2)

Test 7.15: Phase Velocity

A wave traveling in a lossless, nonmagnetic medium has an electric field amplitude of 47.56 V/m and an average power density of 6 W/m^2. Determine the phase velocity of the wave.

(a) $u_p = 3 \times 10^8$ m/s
(b) $u_p = 1 \times 10^8$ m/s

(c) $u_{\mathrm{p}} = 1.5 \times 10^8$ m/s
(d) $u_{\mathrm{p}} = 0.75 \times 10^8$ m/s

Test 7.16: Radar Safe Region

At microwave frequencies, the power density considered safe for human exposure is 1 (mW/cm^2). A radar radiates a wave with an electric field amplitude E that decays with distance as $E(R) = (1{,}000/R)$ (V/m), where R is the distance in meters. What is the radius of the unsafe region?

(a) $R = 1$ km
(b) $R = 75$ m
(c) $R = 167$ m
(d) $R = 11.52$ m