Assignment -4 solutions.

1. (C) for N element linear array of inter element spacing of $\frac{\lambda_0}{4}$, fed with equal amplitude, phase difference b/w consecutive elements should be 90° for end fire radiation pattern. (C)

2. (b) Beam angle $\phi_m = 60°$

to avoid grating lobes $\frac{d}{\lambda_0} \le \frac{1}{1+|\cos\phi_m|}$

$$\frac{d}{\lambda_0} \le \frac{1}{1+\cos 60°}$$

$$d \le 0.667\lambda_0$$

Maximum separation between elements is $0.667\lambda_0$ (b)

3. (d) $N=8$ $d=0.6\lambda_0$ $\phi=60°$

phase difference $\delta = \beta d \cos\phi$

$$\delta = \frac{2\pi}{\lambda_0} \times 0.6\lambda_0 \cos 60°$$

$$\delta = 1.88 \text{ radia}$$

$$\delta(\text{deg}) = 1.88 \times \frac{180}{\pi} = 108°$$

Phase difference b/w each element should be 108° (d)

Common data : $n=10$ $d=0.6\lambda_0 \Rightarrow d_\lambda = 0.6$

4. (b) Directivity $D = 2L_\lambda \Rightarrow D = 2(n-1)d_\lambda \Rightarrow D = 2\times(10-1)\times 0.6$

$$D = 10.8$$

Directivity in dBi $= 10\log D \Rightarrow D = 10.3$ dBi

Approx. directivity of array is 10.3 dBi (b)

5. (C).

$L_1 = (n-1)d_1 = 9 \times 0.6 = 5.4$

Approx. HPBW $= \frac{50.8}{L_1} = \frac{50.8}{5.4} \simeq 9.4°$

Approx HPBW of array is 9.4° (C)

6. (a)

direction of null $\phi_0 = \cos^{-1}\left(\frac{k\lambda}{nd}\right)$

K=1 first null

$\phi_0 = \cos^{-1}\left(\frac{1 \times \lambda_0}{10 \times 0.6\lambda_0}\right)$

$\phi_0 = 80°$

direction from broadside $= 90 - \phi_0 = 10°$ (a)

7. (d).

Direction of first SLL $\psi = \pm \frac{(2K+1)\pi}{n}$ K=1

$\beta d\cos\phi = \frac{(2K+1)\pi}{n}$

$\frac{2\pi}{\lambda_0} \times 0.6\lambda_0 \cos\phi = \frac{3\pi}{10}$

$\phi = \cos^{-1}\left(\frac{3}{10 \times 1.2}\right)$

$\phi = 75.5°$

Direction from broadside $= 90 - \phi = 14.5°$ (d)

8. (b)

Magnitude of SLL $AF = \frac{1}{n\sin\left(\frac{(2K+1)\pi}{2n}\right)}$ K=1, n=10

$AF = 0.22$

Magnitude of first SLL in dB $= 20\log AF = \boxed{-13\text{ dB}}$ (b)

9. (d). $m=10,\ d_x=0.65\lambda_0,\ n=8,\ d_y=0.5\lambda_0$

$L_{x\lambda}=(m-1)d_{x\lambda}$
$=(10-1)\times 0.65$
$=5.85$

$L_{y\lambda}=(n-1)d_y$
$=(8-1)\times 0.5$
$=3.5$

$D_{x\lambda}=2L_{x\lambda}$
$D_{x\lambda}=11.7$

$D_y=2L_{y\lambda}$
$D_y=7$

Assume $\eta=100\%$.

$D=\pi D_x D_y \cos\theta_0$ $\quad\theta_0=0$ for broadside

$G=\eta D$

$G=\pi D_x D_y$

$G=\pi\times 11.7\times 7$

$G=257.3$

Gain in dBi $=10\log G \Rightarrow G(dBi)\simeq 24\,dBi$

Approx. gain of array is 24dBi (d)

Common data: $d_x=d_y=0.5\lambda_0 \Rightarrow d_{x\lambda}=d_{y\lambda}=0.5$

$\theta_E=13^\circ\quad \theta_H=8^\circ$

10. (a) No of elements in E plane $L_{x\lambda}=\dfrac{50.8}{\theta_E}=3.91$

$(m-1)d_{x\lambda}=3.91$

$(m-1)\times 0.5=3.91$

$m=8.81\Rightarrow m\simeq 9$

No of elements in H plane $L_{y_\lambda} = \frac{50.8}{\theta_H} = 6.35$

$(n-1)\, d_{y_\lambda} = \frac{50.8}{8}$

$n = 13.7 \simeq n \simeq 14$

So the number of elements in array is 9×14 (a)

11. (b) Maximum gain of array $G = \pi D_x D_y \cos\theta_0$

$\theta_0 = 0$

$G = \pi \cdot 2L_{x_\lambda} \cdot 2L_{y_\lambda}$

$G = \pi \times 2 \times 3.91 \times 2 \times 6.35$

$G = 312$

Gain in dBi $= 10\log G = 24.95 \simeq 25\,\text{dBi}$

Maximum gain of antenna is 25 dBi (b)

12. (C). $\theta = 30°, \phi = 40°$

$K = \frac{2\pi}{\lambda_0}$

Phase difference in x direction $\beta_x = K d_x \sin\theta_0 \cos\phi_0$

$\beta_x = \frac{2\pi}{\lambda_0} \times 0.5\lambda_0 \sin 30° \cos 40°$

$\beta_x = 1.2\ \text{rad} = 1.2 \times \frac{180}{\pi} \simeq 69°$

Phase diff in y direction $\beta_y = K d_y \sin\theta_0 \sin\phi_0$

$\beta_y = \frac{2\pi}{\lambda_0} \times 0.5\lambda_0 \times \sin 30° \sin 40°$

$\beta_y \simeq 58°$

Answer is (C) 69°, 58°