LARBI BEN M'HIDI OUM EL BOUAGHI UNIVERSITY
INSTITUTE OF APPLIED SCIENCES AND TECHNIQUES
NETWORKS AND TELECOMMUNICATIONS DEPARTMENT

M1 S2

Module: Antennas and radiation

FINAL EXAM G:.....

surname&first name:.....

course questions: (08 pts)

1. give the expression for the radiation intensity U and that for the radiation density Ppoy

(1) $U(\theta,\varphi) = \frac{dP}{d\Omega}$ (W/S.r)

$P_{poy} = \frac{dP}{dS}$ (W/m²)

2. what is the difference between gain and directivity

1 $G = \eta D$; η : rendement / efficacité de l'antenne

3. Mention the three radiation zones and their limits.

1.5 1/ Reactive zone $R < 0,62\sqrt{D^3/\lambda}$

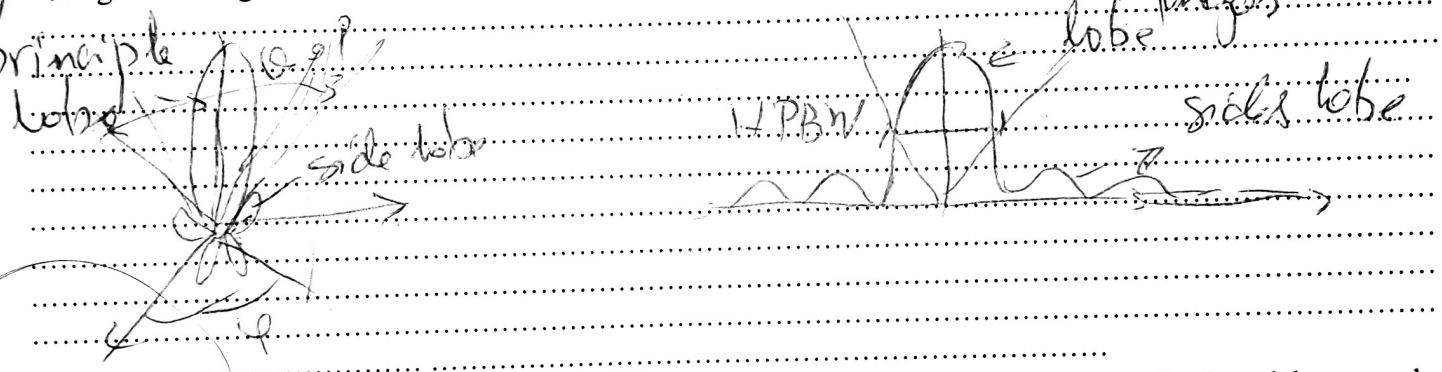
2/ near field zone $0,62\sqrt{D^3/\lambda} < R < 2D^2/\lambda$ (Fresnel)

3/ Far Field zone $R > 2D^2/\lambda$ (Franhofer)

4. Name the three modes of polarization of an electromagnetic wave.

1.5 - Linear
- circular
- Elliptical

(1) 5. give the diagram of the 2D and 3D radiation diagram, citing the different parts



(2) 6. We consider N vertical antennas, spaced d apart and powered by currents of the same amplitude and the same phase

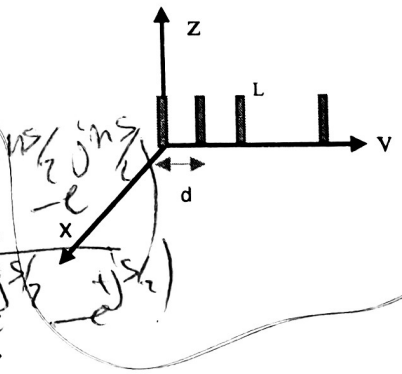
- Give the expression for the modulus of the E field radiated by this grouping

$\underline{E}_{tot} = \underline{E}_1 + \underline{E}_2 + \underline{E}_3 + \underline{E}_4 + \dots + \underline{E}_N$

$= \underline{E}_1 \left(1 + e^{j\psi} + e^{j2\psi} + e^{j3\psi} + \dots + e^{j(N-1)\psi}\right)$

$= \underline{E}_1 \left(\frac{1 - e^{jN\psi}}{1 - e^{j\psi}}\right) = \underline{E}_1 \frac{e^{jN\psi/2}\left(e^{-jN\psi/2} - e^{jN\psi/2}\right)}{e^{j\psi/2}\left(e^{-j\psi/2} - e^{j\psi/2}\right)}$

$= \underline{E}_1 e^{+j(N-1)\psi/2} \frac{\sin N\psi/2}{\sin \psi/2}$



$\psi = \beta d \cos\alpha + \varphi$

Module: Antennas and radiation **M1 S2**

- Define total characteristic function (radiation)

$F(\theta,\varphi) = F_i(\theta) \cdot C(\theta,\varphi) \quad / \quad C(\theta,\varphi) = \frac{\sin^n(n\psi/2)}{\sin(\psi/2)}$

Exercise 01

An antenna emits a signal with a total power of 10 watts. We measure a radiation intensity which follows the following expression:

$$U(\theta,\varphi) = \begin{cases} B.\cos^2(\theta)\ [w/sr]\ pour\ 0 \le \theta \le \frac{\pi}{2};\ et - \pi \le \varphi \le +\pi \\ 0 \qquad\qquad ailleurs \end{cases}$$

1. Find the correct value of B
2. Determine the surface power density at a distance of 1000m
3. Find the maximum directivity in value and dB

Exercise 02

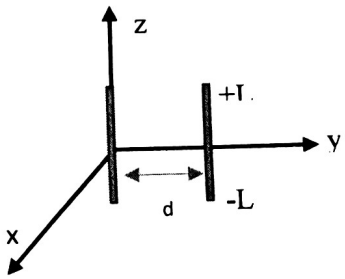
An isotropic antenna radiates a power of 20W at 5cm wavelength. Determine :

1. antenna gain
2. The transmission frequency.
3. The radiated power density at 100 km.
4. Radiation intensity

Exercise 03:

We consider a uniform network of 2 identical Hertz doublets of length 2L (same amplitude of the supply current), regularly spaced by a distance d. Knowing that these doublets are parallel and are contained in the same yoz plane , the current

$$I(z) = I_M e^{j\beta z}$$



1. Give the expression for the field of antenna 2?
2. Give the expression for the total field?
3. Deduce the characteristic radiation function of the group? knowing that $F_i(\theta) = \frac{\cos(\frac{\pi}{2}\cos\theta)}{\sin\theta}$

$\underline{E}_2 = \underline{E}_1 \cdot e^{js} \quad / \quad s = \beta d \sin\theta \sin\varphi$

$\underline{E}_{tot} = \underline{E}_1 + \underline{E}_2 = \underline{E}_1 + \underline{E}_1 e^{js}$

$= \underline{E}_1 (1 + e^{js})$

$= \underline{E}_1 e^{js/2} \left(e^{js/2} + e^{-js/2} \right)$

$\underline{E}_{tot} = 2\underline{E}_1 e^{js/2} \cos(s/2)$

$F(\theta,\varphi) = F_i(\theta) \cdot C(\theta,\varphi) = \frac{\cos(\frac{\pi}{2}\sin\theta)}{\sin\theta} \cdot \cos(\frac{\psi}{2})$

$$U(\theta,\varphi) = \begin{cases} B.\cos^2(\theta)\,[w/sr]\ pour\ 0 \le \theta \le \frac{\pi}{2};\ et\ -\pi \le \varphi \le +\pi \\ 0 \qquad\qquad ailleurs \end{cases}$$

1. Trouver la valeur de B qui convient
2. Déterminer la densité surfacique de puissance à une distance de 1000m
3. Trouver la directivité maximale en valeur et en dB

// $P_{rad} = \iint_{\Omega} U(\theta,\varphi)\, d\Omega = \int_{\varphi}\int_{\theta} B\cos^2\theta \sin\theta \, d\theta\, d\varphi$ / $(\cos^3\theta)' = -3\cos^2\theta\sin\theta$

$= \frac{B}{3}\int_{-\pi}^{\pi} d\varphi \int_{0}^{\frac{\pi}{2}} -3\cos^2\theta\sin\theta\, d\theta = -\frac{B}{3}(2\pi)\left[\cos^3\theta\right]_{0}^{\frac{\pi}{2}} = \frac{B}{3}2\pi =$

$\Rightarrow B = \frac{15}{\pi}$ ou

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Module : Antennes et rayonnements

2/ $|P| = \frac{U(\theta,\varphi)}{R^2} = \begin{cases} \frac{15}{\pi 10^6}\cos^2\theta & ; 0 < \theta < \frac{\pi}{2} \\ 0 & \text{ailleurs} \end{cases}$; $-\pi < \varphi < \pi$

3/ $P_{max} = 4\pi \frac{U_{max}}{P_{rayonnée}}\Big|_{\theta=0} = 4\pi \frac{15}{\pi 10^6} = 6$; $D_{max\,dB} = 7{,}78\,dB$

Exercice 02

Une antenne isotrope rayonne une puissance de 20W à 5cm de longueur d'onde. Déterminer :

a. Le gain de cette antenne.
b. La fréquence d'émission.
c. L'intensité de rayonnement
d. La densité de puissance rayonnée à 100 Km.

a/ $G = 1$ (1) ; $\lambda = 0{,}05$ m.

b/ $f = \frac{C}{\lambda} = \frac{3.10^8}{5.10^{-2}} = 6\,GHz$; c/ $G = \frac{P(\theta,\varphi)}{\frac{P_t}{4\pi}} = 1 \Rightarrow U(\theta,\varphi) = \frac{P_{rad}}{4\pi} = 1{,}59\,W/sr$

d/ $P_{ray} = \frac{U}{R^2} = \frac{P_{ray} G_e}{4\pi d^2} = \frac{20}{4\pi |10^5|^2} = 1{,}59.10^{-10}\,(W/m^2)$.

Exercice 03