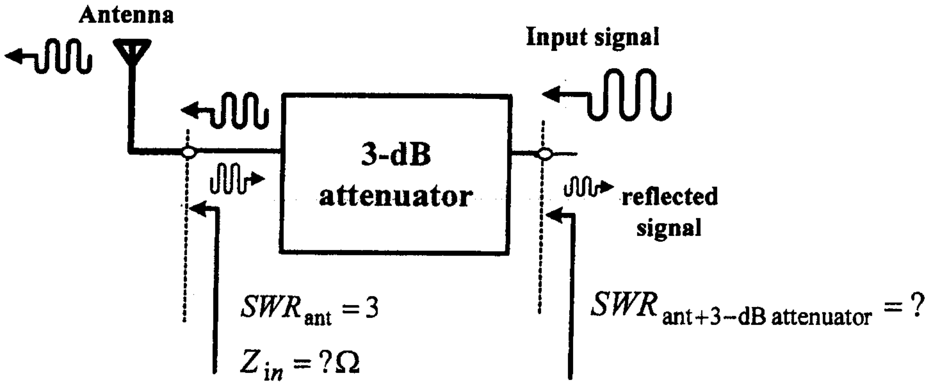
* Useful constants: $\varepsilon_0 = 10^{-9}/36\pi$; $\mu_0 = 4\pi \times 10^{-7}$; $\eta_0 = 120\pi$

1. If the input SWR of an antenna is $\boldsymbol{SWR_{ant}=3}$, what is the $\boldsymbol{SWR_{ant+3\text{-}dB\ attenuator}}$ when the antenna is connected to a 3-dB attenuator (the attenuator is perfectly matched in a 50-Ω system: $S_{12}=S_{12}=0.707$, $S_{11}=S_{22}=0$)? **(10%)**



2. A 1-GHz EM plane wave is normally incident on an infinitely-long aluminum metal plate. Determine the ratio of the **reflected power (P_r)** to the **incident power (P_i)**. **(20%)**

*** Note**

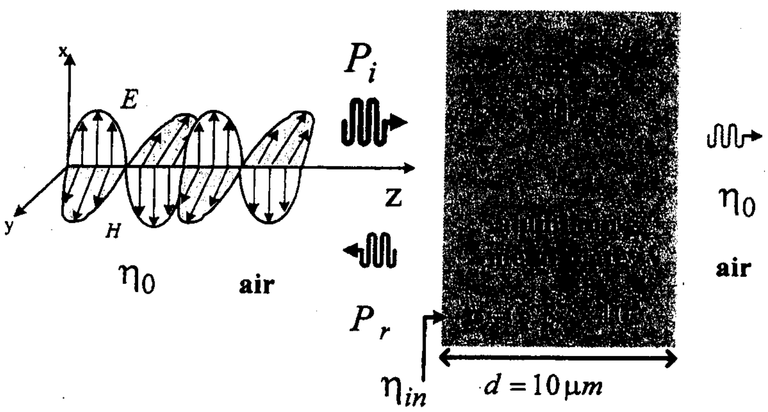
(1) For a good conductor, the propagation constant γ and intrinsic impedance η_c can be approximated as

$$\gamma = \alpha + j\beta = j\omega\sqrt{\mu\varepsilon(1+\tfrac{\sigma}{j\varepsilon\omega})} \approx \sqrt{\pi f \mu\sigma} + j\sqrt{\pi f \mu\sigma}$$

$$\eta_c = \sqrt{\mu/\varepsilon_c} = \sqrt{\mu/\varepsilon(1-j\tfrac{\sigma}{\varepsilon\omega})} \approx (1+j)\sqrt{(\pi f\mu)/\sigma} = \sqrt{(\omega\mu)/\sigma}\angle 45^o$$

(2) η_{in} can be determined by using a **transmission-line analogy** for the input impedance Z_{in} of a **lossy transmission line** (Z_1) with a **length d** and a **load** Z_L

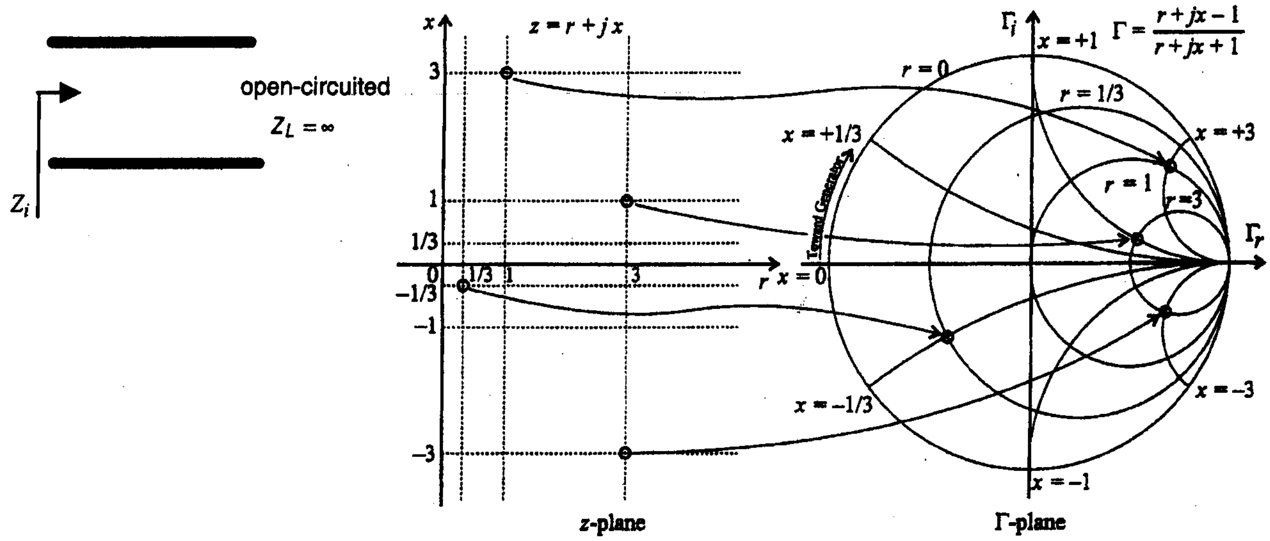
$$Z_{in} = Z_1 \frac{Z_L + Z_1 \tanh(\gamma d)}{Z_1 + Z_L \tanh(\gamma d)}$$



3. For an **open-circuited** 50-Ω transmission line operated at **3 GHz** and with a phase velocity of **0.77 *C*** (the speed of light), find the **line length *l* (mm)** to create an **equivalent capacitance** of **2 pF**. **(15%)**

   (a) Using the transmission line impedance formula: $Z_i = Z_0 \dfrac{Z_L + jZ_0 \tan(\beta l)}{Z_0 + jZ_L \tan(\beta l)}$

   (b) Using the Smith Chart. Draw a simple figure of the Smith chart transformation for this solution.



4. An **automotive tunnel (汽車隧道)** with a rectangular cross section (*width a* = 15m & *height* $b = 6$ m) has **aluminum metallic walls** ($\sigma_c = 4\times 10^8$). If this tunnel is treated as a **waveguide** :

   (a) Determine the **lowest frequency** of the radio wave that will propagate through this tunnel and write down the mode (TE_{mn} or TM_{mn}) of this wave. **(5%)**

   (b) Let the **length of the tunnel** is **100 m** and a **12-MHz radio wave** propagating into this tunnel. Find the **total attenuation** (dB) of this radio wave through this tunnel. **(10%)**

   (c) Determine the VSWR of the radio wave at the end of the tunnel-waveguide (like having a free-space load). **(10%)**

Note: *Waveguide wavelength and TE_{10}-mode impedance*

$$\lambda_g = \lambda \Big/ \sqrt{1-(f_c/f)^2} \quad \& \quad Z_{TE} = \eta_0 \Big/ \sqrt{1-(f_c/f)^2}$$

Waveguide TE_{10} mode attenuation constant :

$$\alpha_{c_{TE10}} = \frac{\lambda}{b\lambda_g}\sqrt{\frac{\pi}{\lambda\eta_0\sigma_c}}\left[1+(\lambda_g/\lambda_c)^2\left(1+2\frac{b}{a}\right)\right]$$

5. A **1-GHz** base-station dipole antenna with a **half-length** L**=0.25** λ is located at a height of H_b **=30 m** and the transmitter power is 20 W. Let the handset antenna has a gain of 0 dBi and input SWR=3. The dipole antenna gain-pattern (dBi) is shown in the figure.

(a) If the cable feeder loss of the base-station antenna is **3 dB**, determine the **antenna radiation power** P_{rad}(W), the **radiation power density** S **(W/m^2)** and **E-field strength** E**(V/m)** at the human operator with d **= 50 m. (20 %)**

(b) If the handset receiver sensitivity is P_{sen}**=-100 dBm and the power absorption rate of the human head to the handset antenna is 50%** , compute the maximum communication distance d . **(10%)**

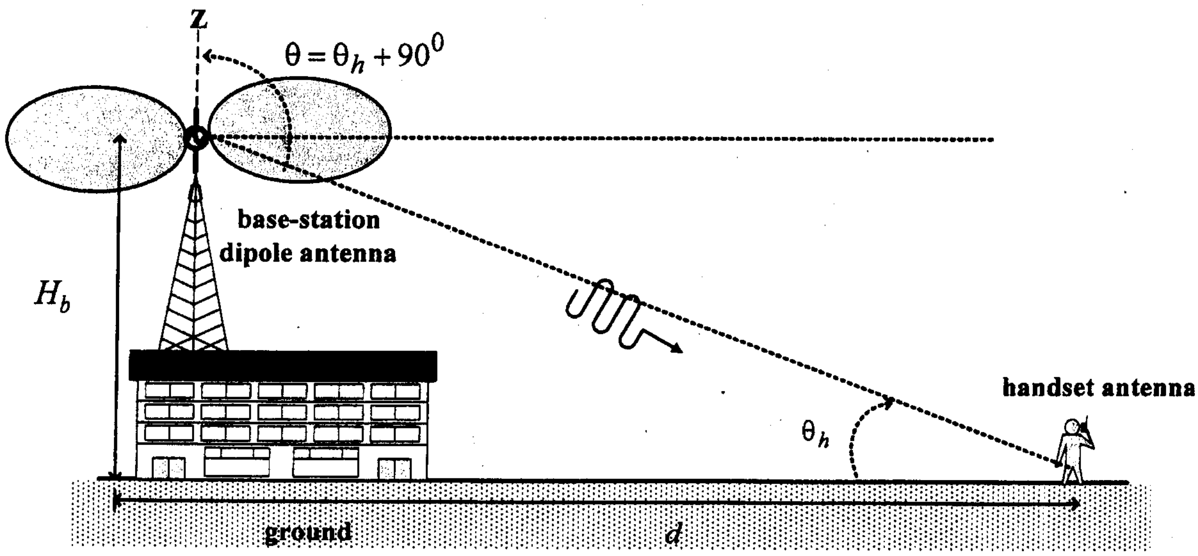
* Note: Neglect the ground effect and assume in **free space.**

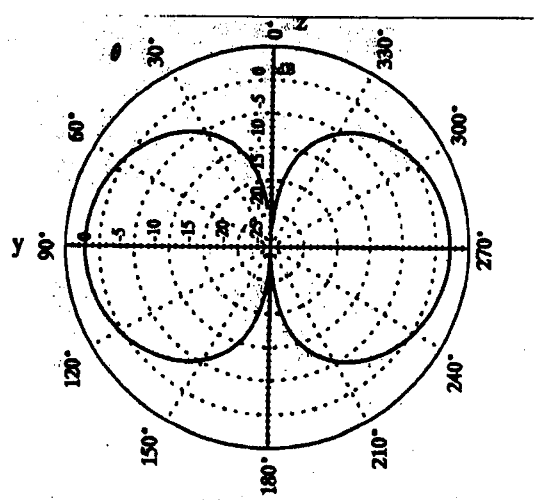
Free-space Friis Power Transmission Formula : $P_r = P_t G_t (\frac{\lambda}{4\pi R})^2 G_r$

P_t : antenna transmitting power G_t : transmitting antenna gain

P_r : antenna receiving power G_r : receiving antenna gain

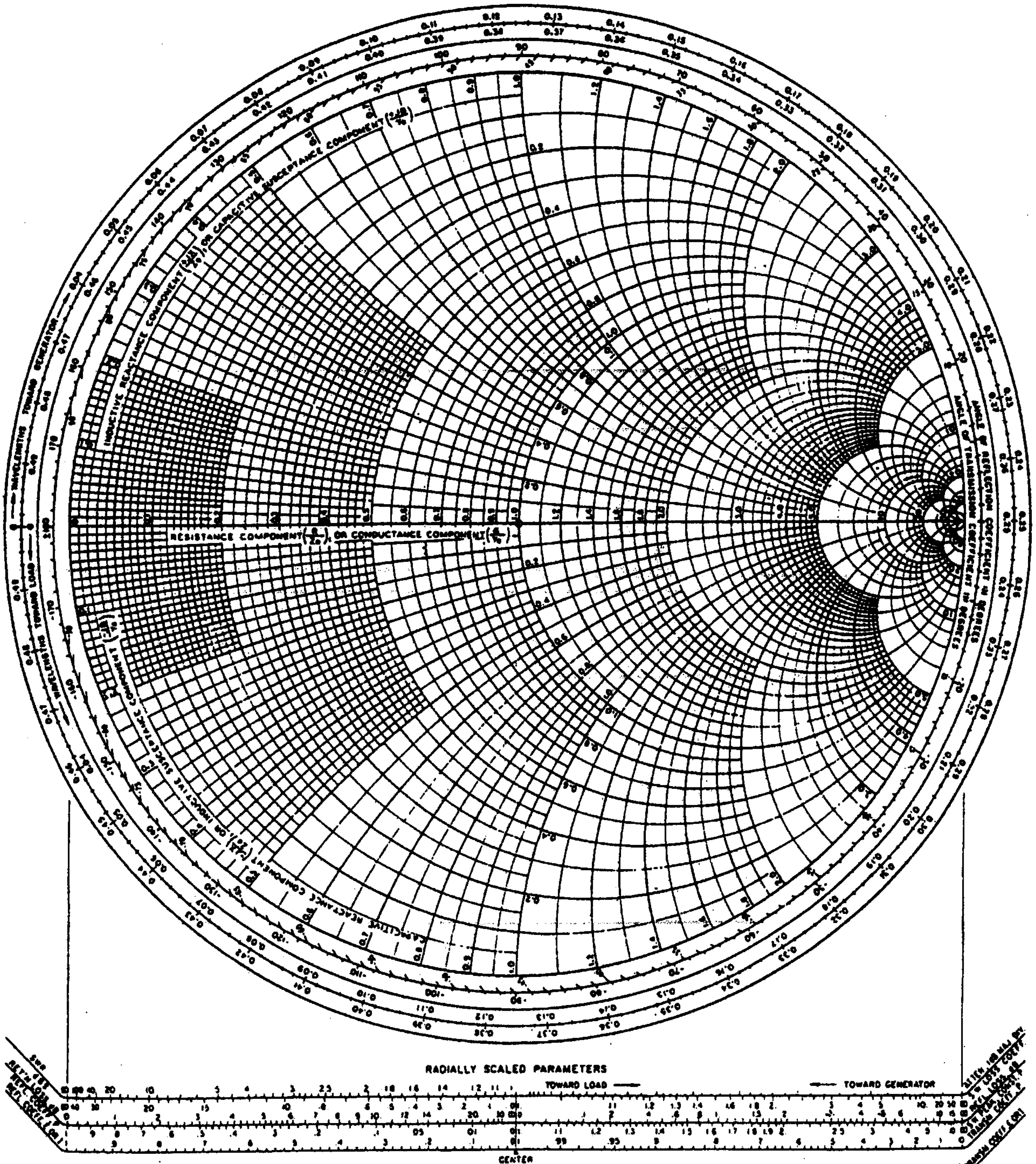
* **The above formula does not include the antenna mismatch loss.**





Half-wavelength Dipole Antenna E-Plane Directive Gain Pattern

（背面仍有題目,請繼續作答）


RESISTANCE COMPONENT (R/Zo), OR CONDUCTANCE COMPONENT (G/Yo)
INDUCTIVE REACTANCE COMPONENT (+jX/Zo), OR CAPACITIVE SUSCEPTANCE COMPONENT (+jB/Yo)
CAPACITIVE REACTANCE COMPONENT (-jX/Zo), OR INDUCTIVE SUSCEPTANCE COMPONENT (-jB/Yo)
WAVELENGTHS TOWARD GENERATOR
WAVELENGTHS TOWARD LOAD
ANGLE OF REFLECTION COEFFICIENT IN DEGREES
ANGLE OF TRANSMISSION COEFFICIENT IN DEGREES
RADIALLY SCALED PARAMETERS
TOWARD LOAD
TOWARD GENERATOR
CENTER
ORIGIN