ECE 3317
Applied Electromagnetic Waves

Final Exam

Dec. 9, 2024

Name: ____

General Information:

The exam is open-book and open-notes. You are not allowed to use any device that has communication functionality (laptop, cell phone, ipad, etc.).

Instructions:

- Show all of your work. No credit will be given if the work required to obtain the solutions is not shown.
- Write neatly. You will not be given credit for work that is not easily legible.
- Leave answers in terms of the parameters given in the problem.
- Show units in all of your final answers.
- Circle your final answers.
- Double-check your answers. For simpler problems, partial credit may not be given.
- If you have any questions, ask the instructor. You will not be given credit for work that is based on a wrong assumption.
- Make sure you sign the academic honesty statement below.

Academic Honesty Statement

By taking this exam, you agree to abide by the UH Academic Honesty Policy during this exam. You understand and agree that the punishment for violating this policy will be most severe, including getting an F in the class and getting expelled from the University.

Signature: ____

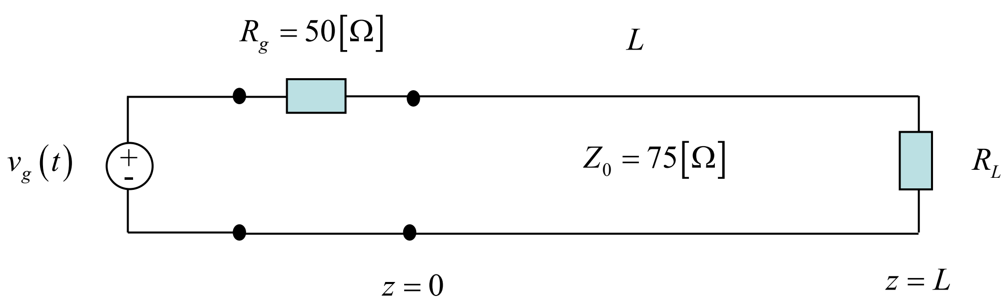
Problem 1 (25 pts)

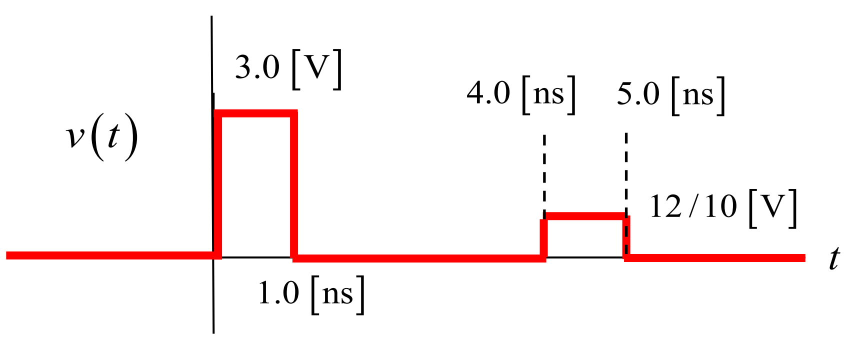
A generator voltage $v_g(t)$ puts out a rectangular pulse function with an amplitude of V_0 = 5 volts and a width of 1.0 [nS]. The generator has a 50 [Ω] Thévenin impedance. The generator is connected to a transmission line having a characteristic impedance of Z_0 = 75 [Ω]. The line is a coaxial cable of length L that is filled with Teflon, having ε_r = 2.1. At the end of the line there is a load R_L. The voltage $v(t)$ at z = 0 is measured, and this is shown in the plot below.

(a) What is the length of the line L in meters?

(b) What is the load resistance R_L?

Make a bounce diagram to show how you are getting your answers.





ROOM FOR WORK

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Problem 2 (25 pts)

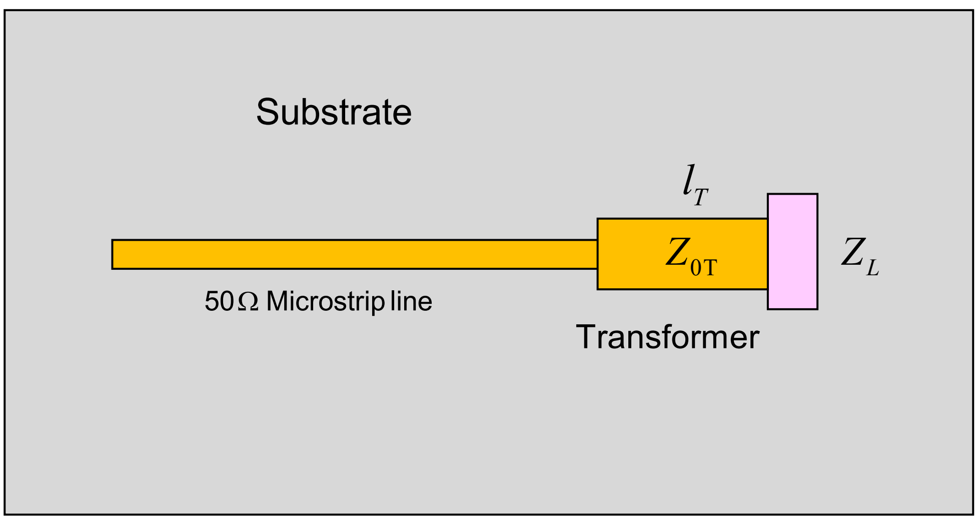
A device (load) on a printed circuit board has an input impedance of $Z_L = 100$ [Ω]. The load is connected to a quarter-wave transformer that is then connected to a 50 [Ω] microstrip line. The frequency is 3 [GHz] and the effective relative permittivity of the transformer line is 1.5.

a) What is the characteristic impedance of the transformer line?

b) What is the length of the transformer line, in cm?

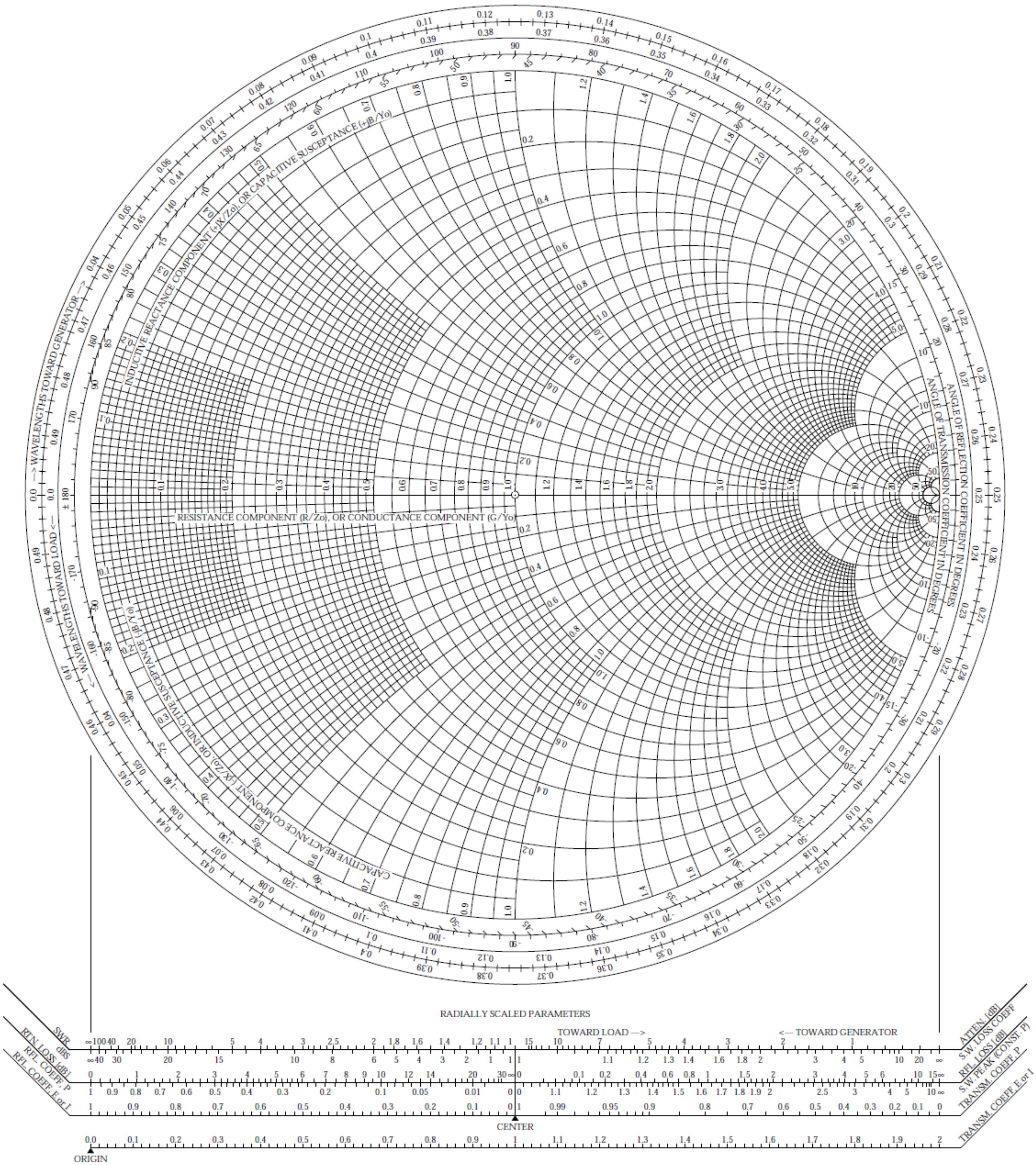
c) Find the input impedance seen by the 50 [Ω] microstrip line looking into the transformer at a frequency of 4 GHz, using the Smith chart.

d) Find the SWR on the 50 [Ω] microstrip line at 4 GHz using the Smith chart.



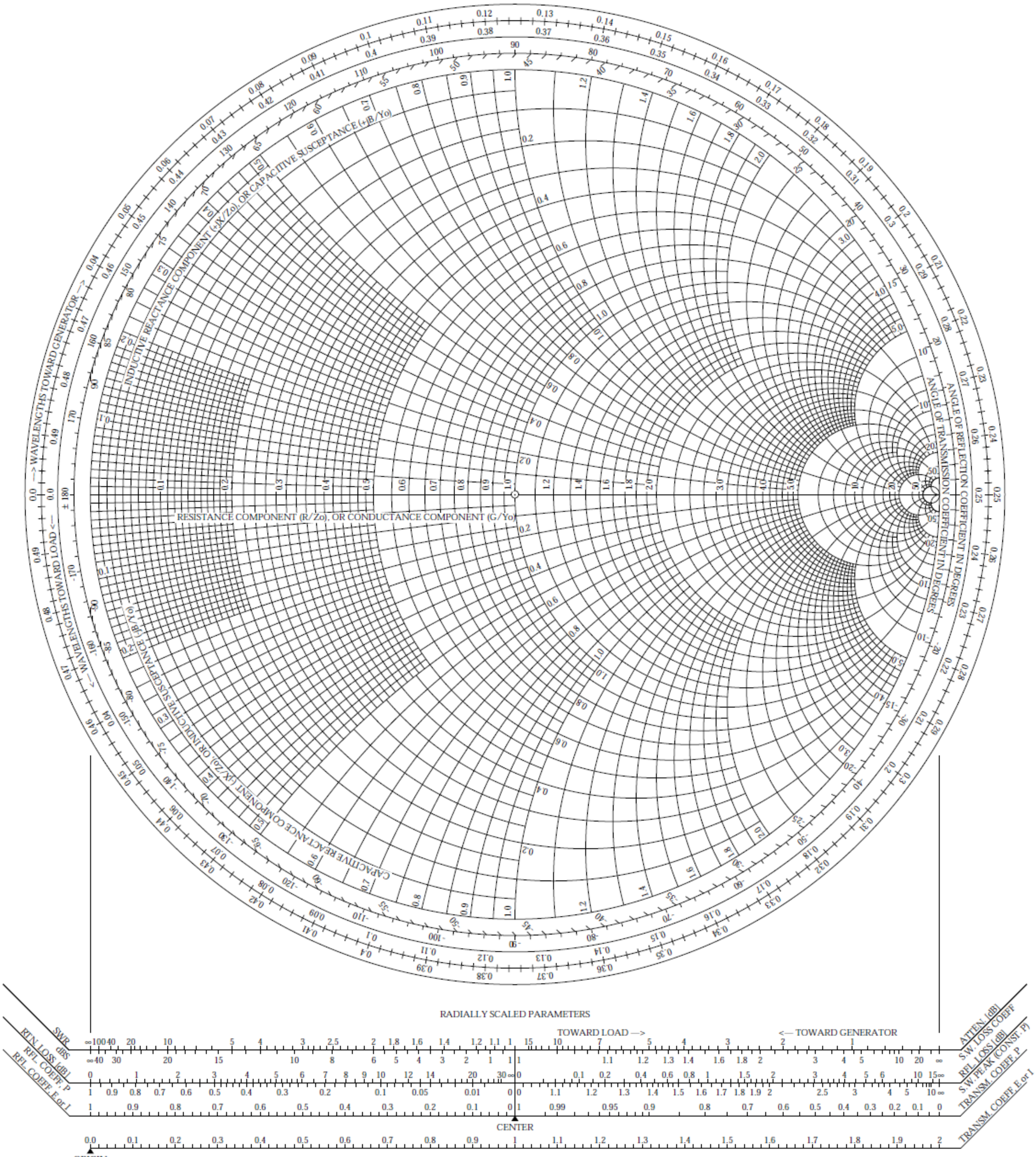
The Complete Smith Chart

Black Magic Design



The Complete Smith Chart

Black Magic Design



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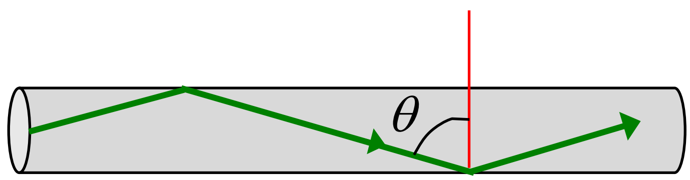
Problem 3 (25 pts)

A laser beam inside of a fiber optic rod is bouncing at an angle of $\theta = 60^o$ as shown below. Assume that the glass fiber has an index of refraction of $n_1 = 1.5$ and the surrounding air region has an index of refraction of $n_2 = 1.0$. At the operating frequency the wavelength in free space is 1.3 [μm]. (1 μm = 10^{-6} meters.) How many dB of attenuation is there in the optical signal at a distance of 1 [μm] from the surface of the fiber in the air region?



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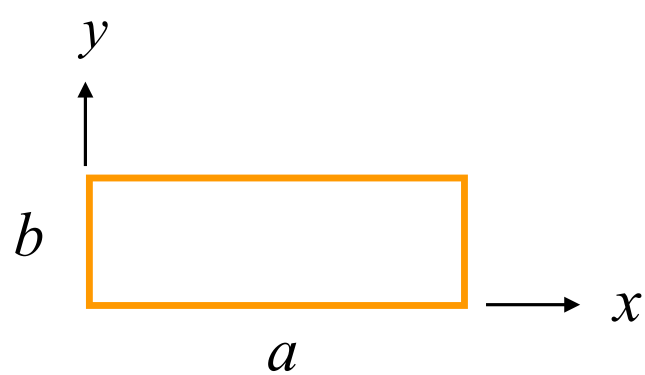
Problem 4 (25 pts)

a) Design the dimensions a and b of an air-filled rectangular waveguide that is to be used for transmission of electromagnetic power at an operating frequency of 8.0 [GHz]. Assume that we choose $b = a/2$. The operating frequency of 8.0 GHz should be at the center of the frequency band that is between the cutoff frequencies of the TE_{10} mode and the TE_{20} mode.

b) Now assume that $a = 1.5$ [cm] and $b = a/2$. At a frequency of 5.0 GHz, how many dB of attenuation is there in the TE_{10} mode after a distance of 5.0 cm?



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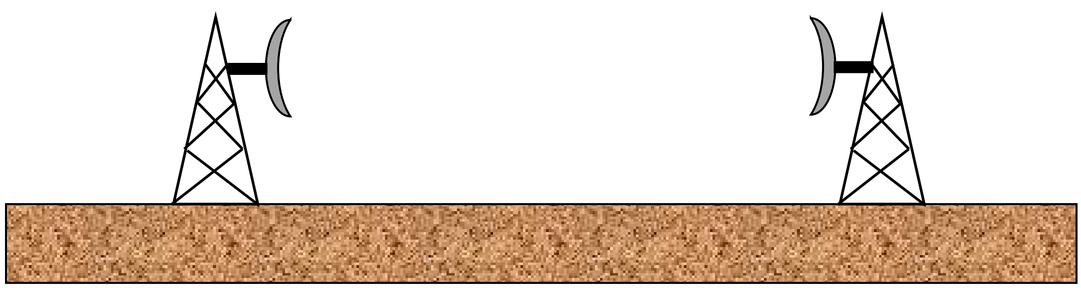
Bonus Problem (30 pts)

A parabolic reflector (dish) antenna has a diameter of 1.0 [m] and an aperture efficiency of 75%. The frequency is 12 [GHz].

a) What is the gain of the dish antenna?

b) Now assume that the dish antenna radiates a power of 10 [W] and the gain of the dish is 1.0×10^4. (Assume this gain number, regardless of what you got for your answer to part (a).) What is the power density [W/m^2] that is radiated at a distance of 10.0 [km] from the dish, in the direction of the main beam?

c) At a distance of 10.0 [km] from the transmitting dish antenna that is transmitting 10 [W] of power, a second identical dish antenna is placed to receive the signal, as shown below. How much power will the receive dish antenna be able to pick up and deliver to a matched load? Assume that both dishes have a gain of 1.0×10^4.



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