ECE 3317
Applied Electromagnetic Waves

Exam 2

Nov. 30, 2023

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.).

Remember, you are bound by the UH Academic Honesty Policy during the exam!

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: _____

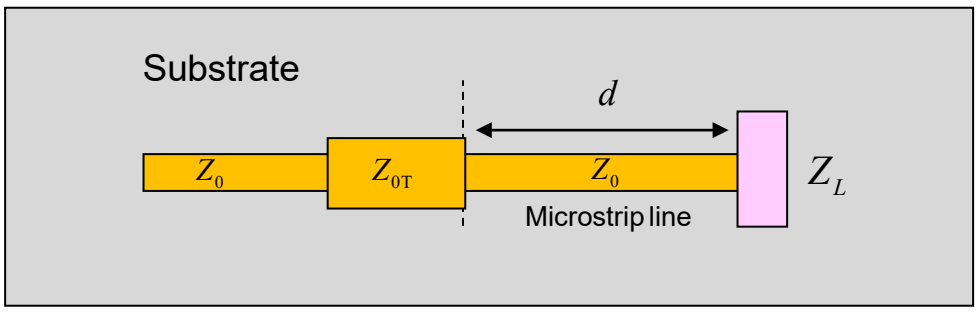
Problem 1 (40 pts)

a) A microstrip line on a circuit board having $Z_0 = 50\,[\Omega]$ is connected to a load impedance $Z_L = 75 + j75\,[\Omega]$. The frequency is 3.0 GHz and the effective relative permittivity of the line is $\varepsilon_r^{\text{eff}} = 1.4$. Find the location $z_{\min}$ of the first voltage minimum on the line (i.e., the one that is closest to the load). Do not use the Smith chart.

b) A microstrip line on a circuit board having $Z_0 = 50\,[\Omega]$ is connected to a load Z_L. The frequency is 5.0 GHz. One voltage minimum occurs at $z_{\min} = -1.0\,[\text{cm}]$. The voltage maximum that is closest to this voltage minimum (going away from the load) is located at $z_{\max} = -2.111\,[\text{cm}]$. Find the effective relative permittivity of the line. Do not use the Smith chart.

c) A microstrip line on a circuit board having $Z_0 = 50\,[\Omega]$ is connected to an unknown load Z_L. The frequency is 4.0 GHz. One voltage minimum occurs at $z_{\min} = -1.5\,[\text{cm}]$. The maximum voltage measured on the line is 4.0 [V] and the minimum voltage measured is 2.0 [V]. The effective relative permittivity of the line is $\varepsilon_r^{\text{eff}} = 1.75$. Find the unknown load impedance using the Smith chart (please show your work on the first Smith chart on the following pages).

d) A microstrip line having $Z_0 = 50\,[\Omega]$ is connected to a load impedance $Z_L = 75 + j75\,[\Omega]$. The frequency is 3.0 GHz and the effective relative permittivity of the line is $\varepsilon_r^{\text{eff}} = 1.4$. Find the distance d in cm (as small as possible) to put a quarter-wave transformer and the characteristic impedance Z_{0T} of the transformer to get a matched system (see the figure below). Use the Smith chart for this problem (please show your work on the second Smith chart on the following pages).

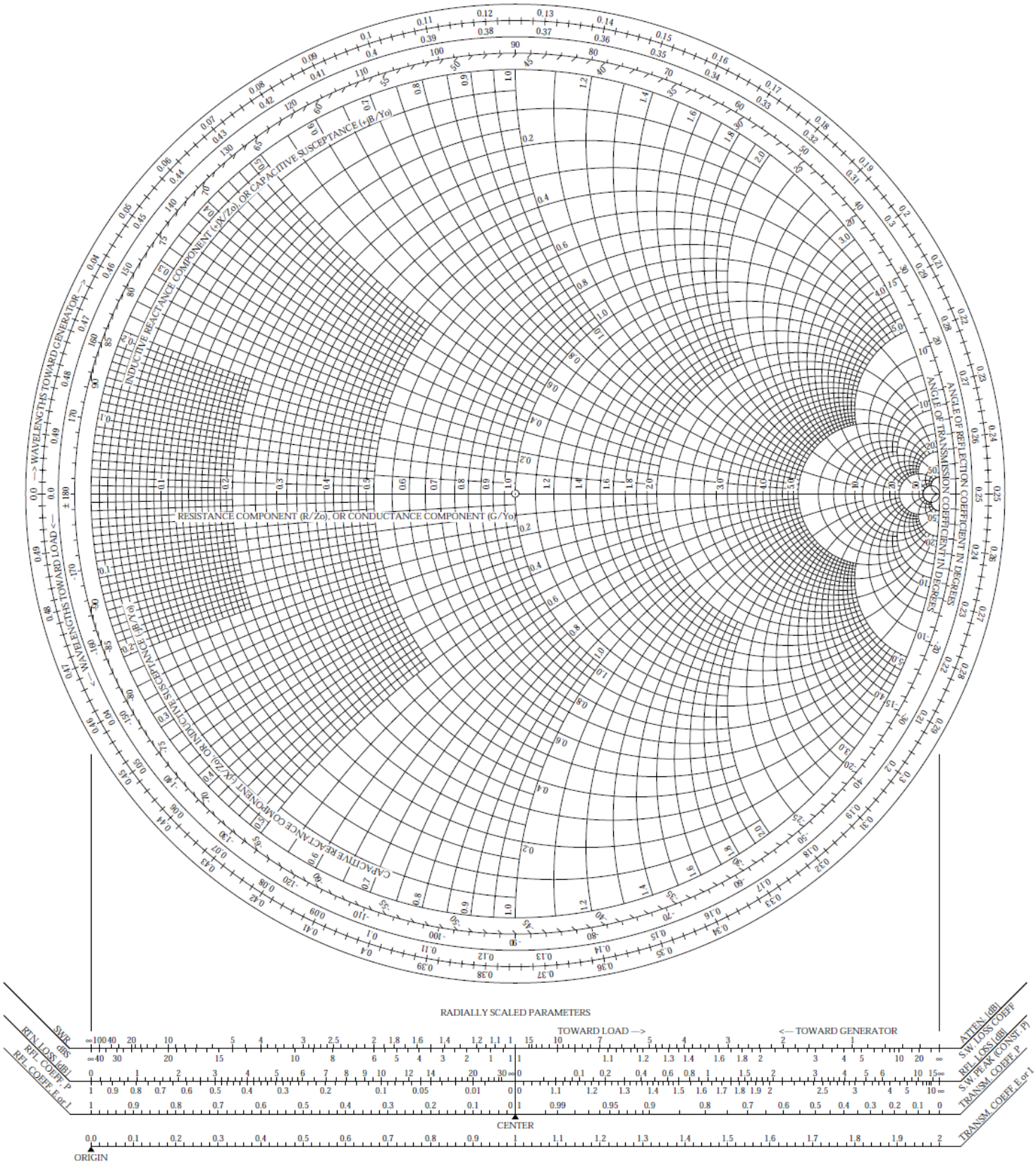


ROOM FOR WORK

ROOM FOR WORK

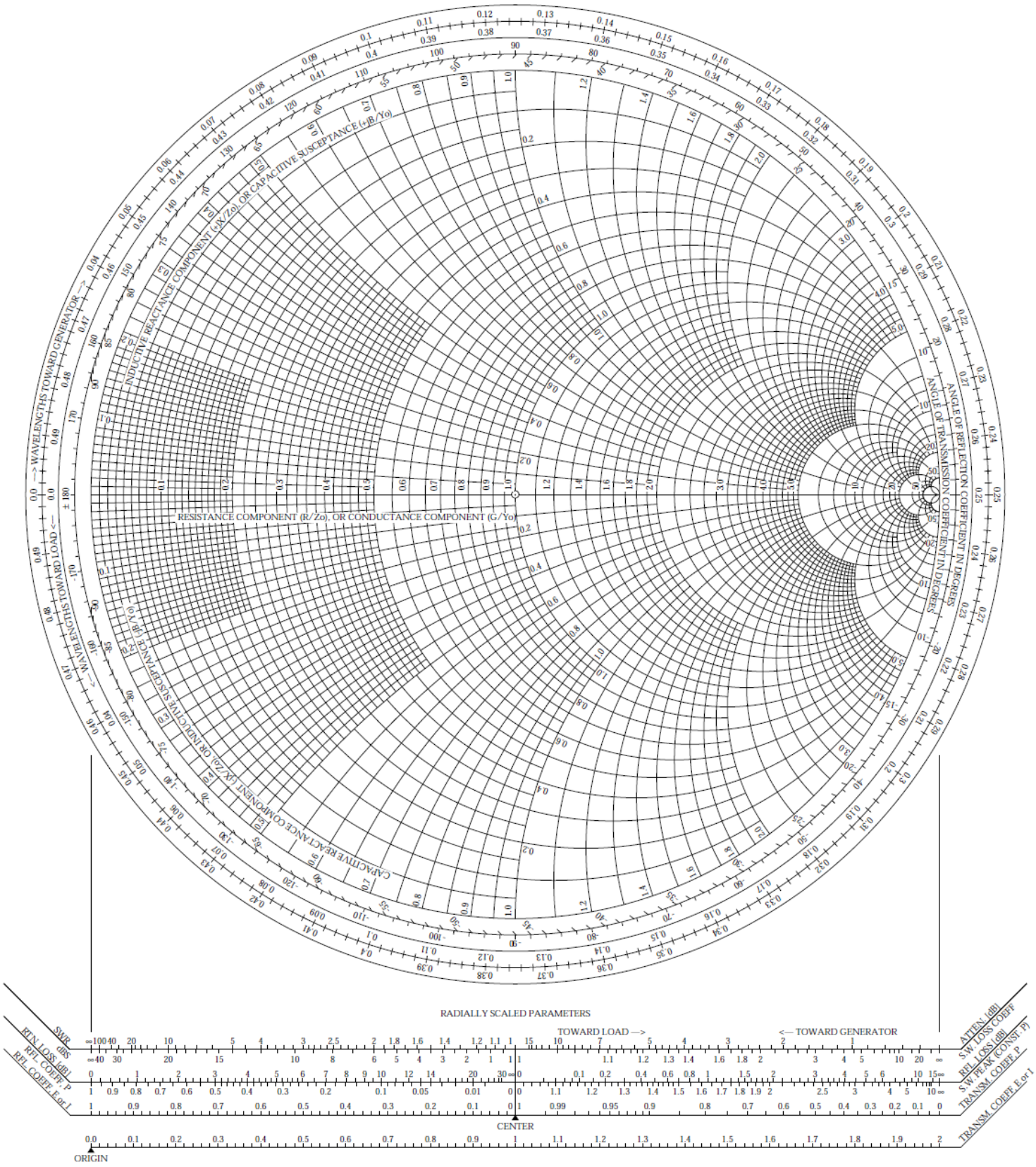
The Complete Smith Chart

Black Magic Design



The Complete Smith Chart

Black Magic Design



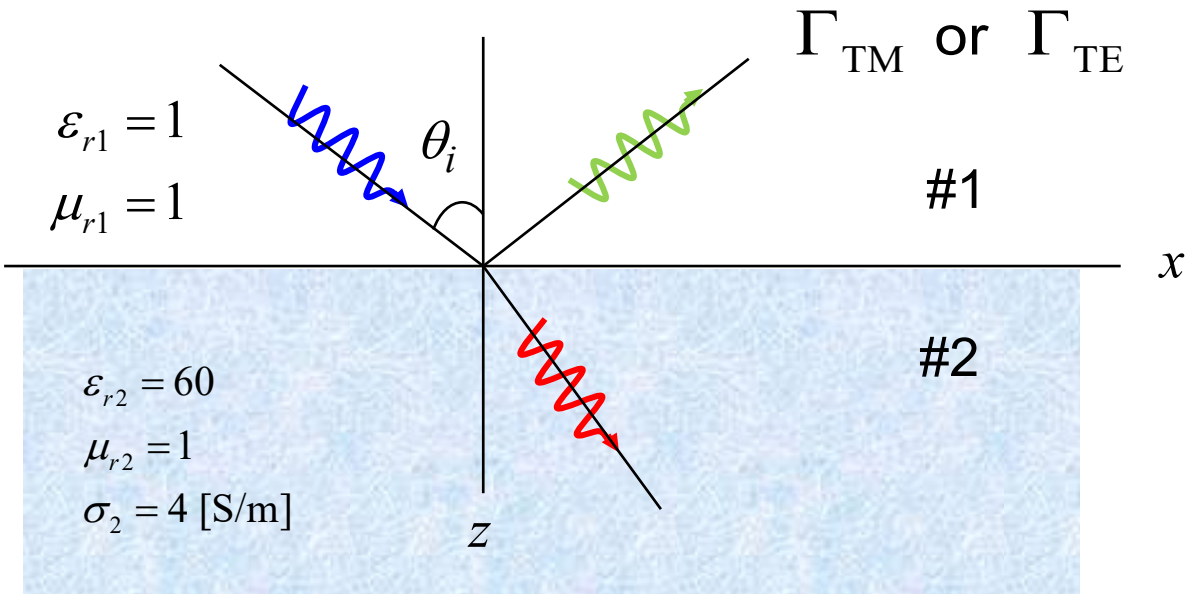
Problem 2 (30 pts)

A plane wave in air is incident on the ocean at 12 GHz. The angle of incidence is $\theta_i = 45^\circ$. The ocean water at this frequency has a relative permittivity of $\varepsilon_r = 60$. The ocean water also has a conductivity $\sigma = 4$ [S/m]. The ocean water is nonmagnetic $(\mu = \mu_0)$.

a) Find the reflections coefficients Γ_{TM} and Γ_{TE}.

b) Find the percentage of power that gets reflected from the surface of the ocean if the incoming wave is a circularly polarized wave.

c) Find the attenuation in [dB/m] inside the ocean water in the vertical direction for this wave.



ROOM FOR WORK

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Problem 3 (30 pts)

A plane wave in air has the following electric field:

$$\underline{E} = \left[(2 + j2)\,\underline{\hat{z}} + (1 - j2)\,\underline{\hat{x}} \right] e^{+jk_0 y}.$$

(a) Classify the polarization of this wave (linear, LHCP, RHCP, LHEP, RHEP).

(b) Find the axial ratio of this wave.

ROOM FOR WORK

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