ECET 3410 – Fall 2016

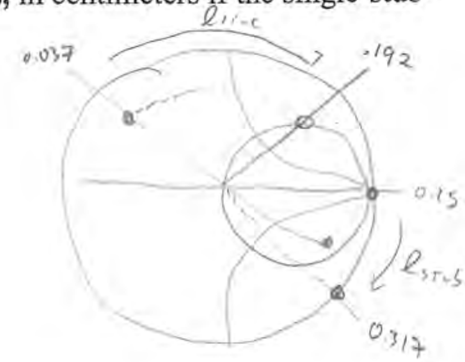
High *f* Systems – Exam II **Print Name (LAST NAME FIRST):** KEY

Instructions: Show all of your work, making sure that your work in legible and that your reasoning can be followed. No credit will be given for illegible or illogical work, or for final answers that are not justified by the work shown. Place all final answers in the spaces provided. This exam is closed book, except for a single 8.5"x11" sheet of handwritten notes which may **NOT** contain any numerically-solved problems.

Coaxial Cables

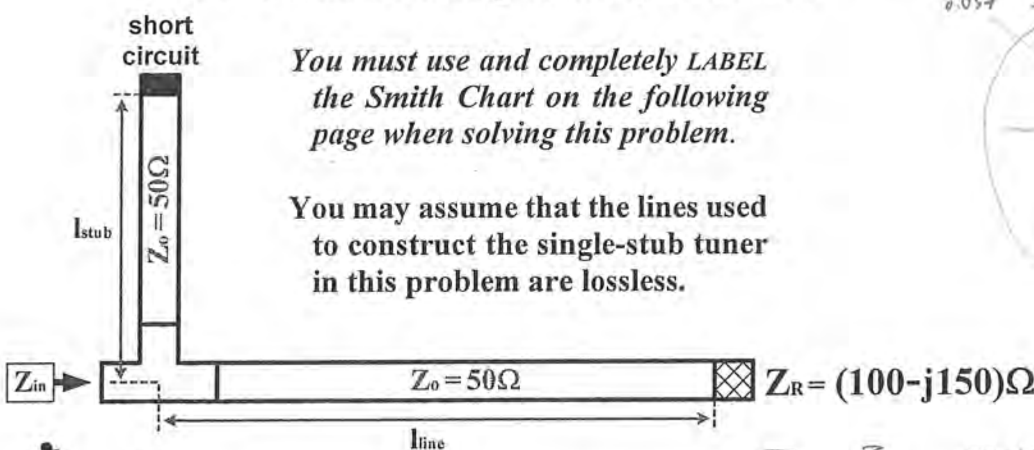
RG #	AWG Material	Insulation	# Shields	Jacket	Nom. O.D. (inch)	Nom. Imp. (Ohms)	Nom. Vel. Of Prop.	Nom. Cap. (pF/ft.)	Nom. Attenuation per 100' MHz	dB	Standard Spool Lengths
14A/U	20 Copper	Poly-ethylene	1	Black Vinyl	.420	92	66%	16.0	100 200 400	3.5 5.0 7.0	100, 500
16A/U	18 Copper	Cellular Poly-ethylene	1	Black Vinyl	.195	50	78%	30.8	100 200 400	2.5 3.5 5.0	100,500 1000
18/U	18 Copper	Cellular Poly-ethylene	1	Black Vinyl	.280	75	78%	24	100 200 400	2.0 3.0 4.5	100,500 1000

Problem #1) A **single-stub tuner**, consisting of a 50Ω main "line" connected in parallel with a 50Ω short-circuited "stub" is used to match a load of $\mathbf{Z_R = (100 - j150)\Omega}$ to a **50Ω, 400MHz** system. Determine the **lengths** of the "line" and "stub", $\mathbf{l_{line}}$ and $\mathbf{l_{stub}}$, in centimeters if the single-stub tuner is constructed using **air-filled**, coaxial lines.



You must use and completely LABEL the Smith Chart on the following page when solving this problem.

You may assume that the lines used to construct the single-stub tuner in this problem are lossless.



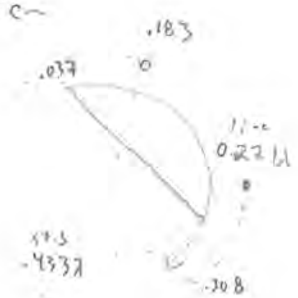
$\bar{Z}_R = \frac{Z_R}{Z_0} = \frac{100-j150}{50} = 2-j3$

$\lambda = \frac{3\times10^8}{400\times10^6} = 75\text{ cm}$

Convert $\lambda \to$ cm

$\ell_{line} = 0.155\lambda \times 75\frac{cm}{\lambda} = \boxed{11.6\text{ cm}}$

$\ell_{stub} = 0.067\lambda \times 75 = \boxed{5.0\text{ cm}}$



2) $Z_{in} = 13.2\,\Omega$
VSWR = 6.9 → 3.8

3) $Z_{load} = 112.5\,\Omega$
$\ell_{trans} = 10$ cm

4) T/F

5) $Z_R = 85 - j72\ \Omega$
$\Gamma_R = 0.5246\angle -56°$
$f = 1364$ MHz

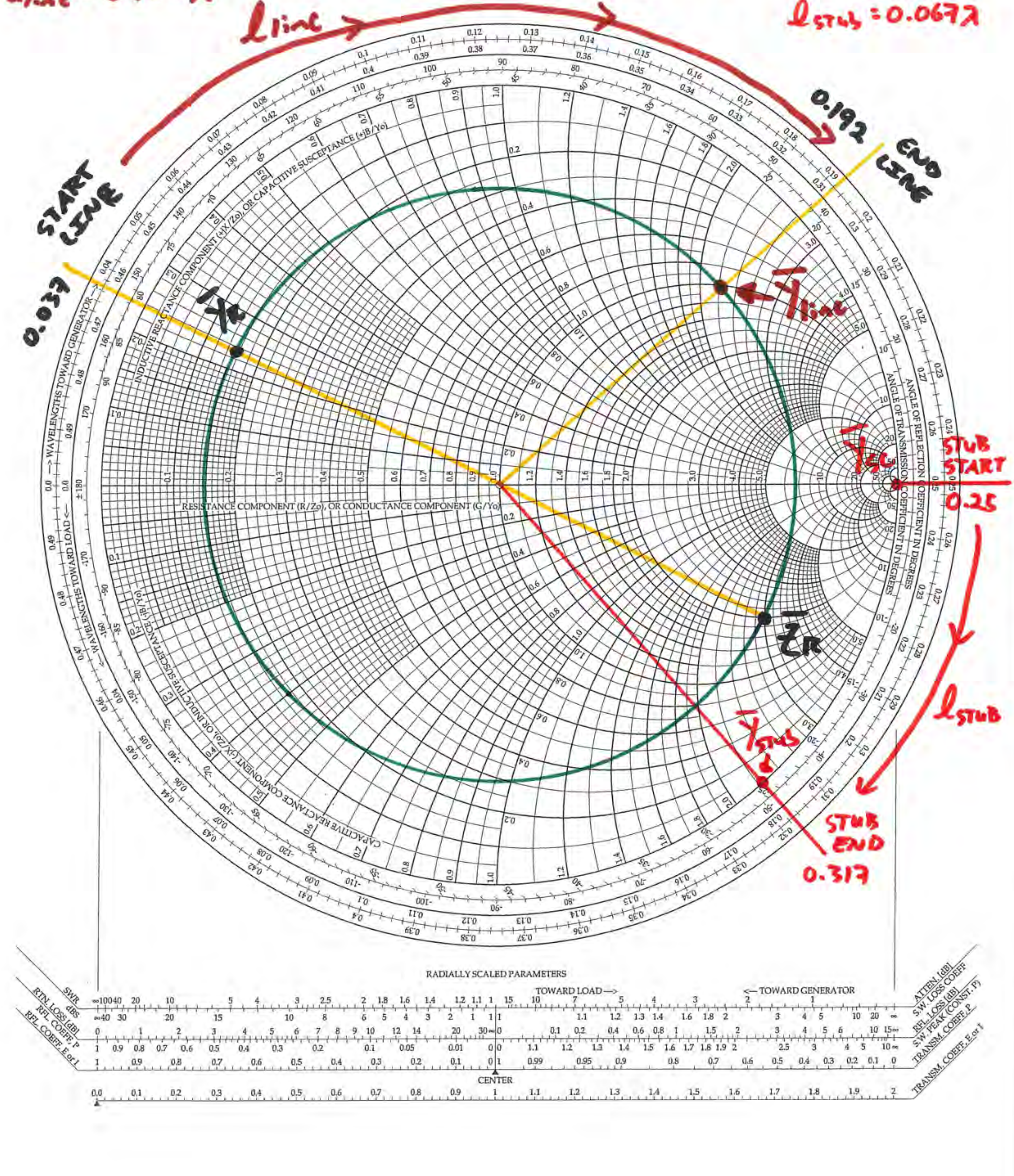
	Soln #1		
l_{line} =	11.6	20.3	cm
l_{stub} =	5.0	32.5	cm

#1

LINE
END 0.192
START −0.037
$l_{line} = 0.155\lambda$

$\bar{Y}_{line} = 1 + j2.22$
$\therefore \hookrightarrow \bar{Y}_{STUB} = -j2.22$

STUB
END 0.317
START −0.250
$l_{STUB} = 0.067\lambda$



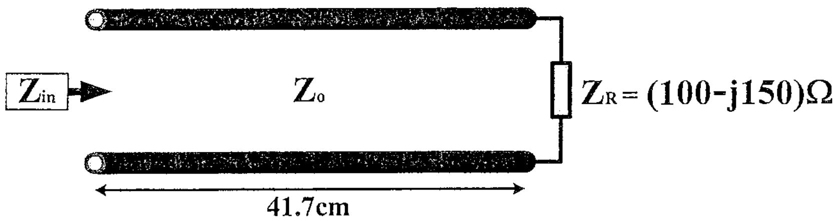
Problem #2) A **41.7cm** long, **lossy** transmission line with the following characteristics:

$Z_o = 50\Omega$, $\gamma = 0.3 + j10.74$ (Np/m and rad/m respectively)

is terminated with a load $Z_R = (100 - j150)\Omega$ and supplied by a **400MHz** source.

Determine the **input impedance, Z_{in}**, of the line and the **VSWR** on the line.

You must use and completely LABEL the Smith Chart on the following page when solving all parts of this problem.



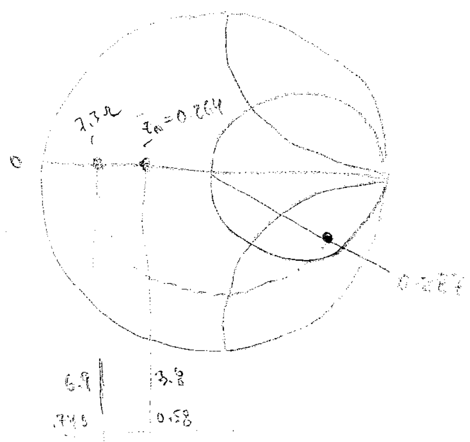
$\bar{Z}_R = 2 - j3$

$\lambda = \frac{2\pi}{\beta} = 0.585\,m = 58.5\,cm$

$\ell : \frac{41.7\,cm}{58.5\,cm/\lambda} = 0.713\lambda$

-0.5

0.213λ



$|\Gamma| = 0.7452$

$|\Gamma_i| = 0.7452\, e^{-2(0.3)(0.417)}$

$= (0.7452)\, e^{-0.2502}$

$= (0.7452)(0.7787)$

$= 0.58$

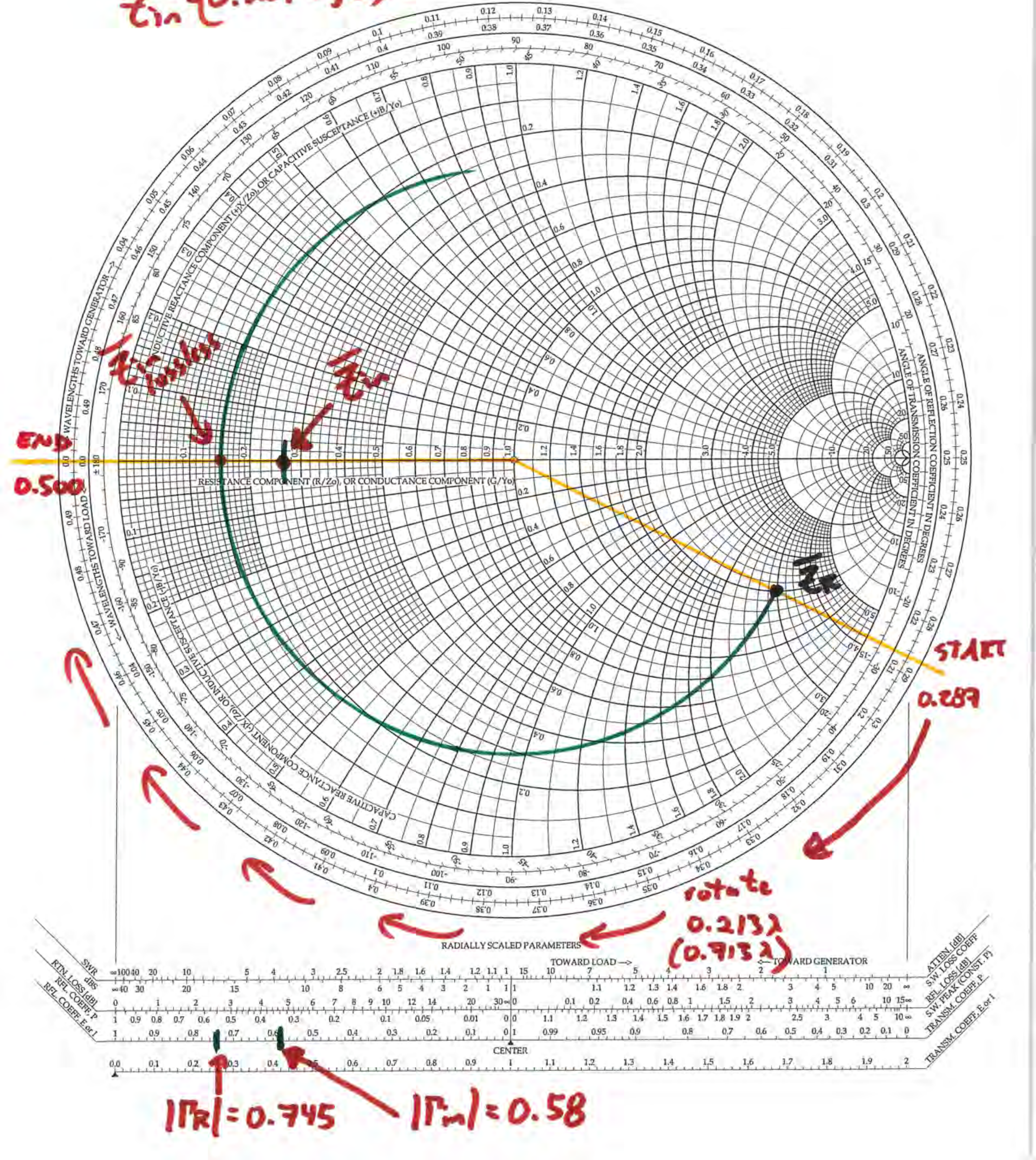
$Z_{in} = \bar{z}_{in} \cdot Z_o = (0.264 + j0)(50) = 13.2\,\Omega$

$Z_{in} =$ 13.2 Ω

VSWR = 6.9 (load) or 3.8 (in)

#2

$\bar{Z}_{in} = (0.264 + j0)\,\Omega$



Problem #3) A section of **RG 18/U** coaxial cable will be used as a **¼-wavelength tuner** to match a load to a **50Ω, 585MHz source**. Assuming that the coaxial cable may be considered lossless due to its short length, determine the value of the **load impedance**, $\mathbf{Z_R}$, and the **length** of the ¼-wavelength tuner, $\mathbf{l_{tuner}}$, in centimeters.

$$Z_{0t} = \sqrt{Z_a Z_{in}}$$

$$\hookrightarrow Z_a = \frac{Z_{0t}^2}{Z_{in}} = \frac{75^2}{50} = \boxed{112.5\ \Omega}$$

$$v = 0.78c = 2.34 \times 10^8 \text{ m/sec}$$

$$\lambda = v/f = \frac{2.34 \times 10^8}{585 \times 10^6} = 0.4 \text{ m} = 40 \text{ cm}$$

$$l = \tfrac{1}{4}\lambda = \tfrac{1}{4}(40) = \boxed{10 \text{ cm}}$$

Z_{Load} = 112.5 Ω

l_{tuner} = 10 cm

Problem #4) Specify whether each of the statements are **TRUE** or **FALSE**.

False — Compared to a ¼-wavelength tuner, a **single-stub tuner** will theoretically provide a better match for a purely real load impedance to a purely real source impedance.

TRUE — A (lossless) **short-circuited stub** of length L can have any desired, purely inductive, input impedance value depending on the length L of the stub.

TRUE — The set of normalized load impedances formed by drawing a circle centered at the origin of a Smith Chart will all result in the same **VSWR** on the transmission-line.

False — The set of normalized load impedances formed by drawing a circle centered at the origin of a Smith Chart will all result in the same **reflection coefficient** on a transmission-line.
magnitude

False — Adding **one wavelength** to the length of a line terminated by a load will result in an additional rotation of 1 revolution on a Smith Chart when solving for Z_{in}.

False — A **¼-wavelength tuner** may be used to match a purely imaginary load (such as the load $Z_R = 0+j200\Omega$) to a 50Ω source.

False — The **circle** that provides the **outer-boundary** of the Smith Chart defines the set of impedances that all have imaginary values of zero (I.e. – purely resistive impedances).

TRUE — The point having the **largest magnitude** within the set of impedances formed by drawing a circle centered at the origin of the Smith Chart will be the "right-most" point on the circle.

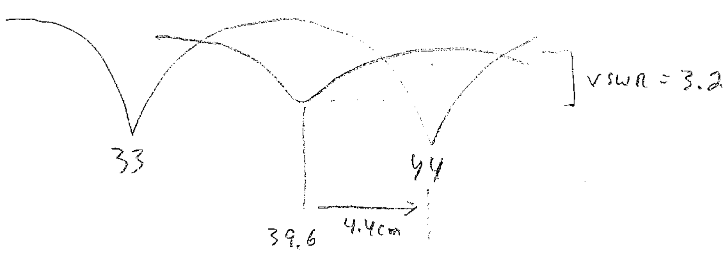
Problem #5) When an **air-filled, 50Ω**, slotted-line is terminated with a "**short-circuit**", **voltage minima** (nulls) are measured at positions of **33cm** and **44cm** on the line.

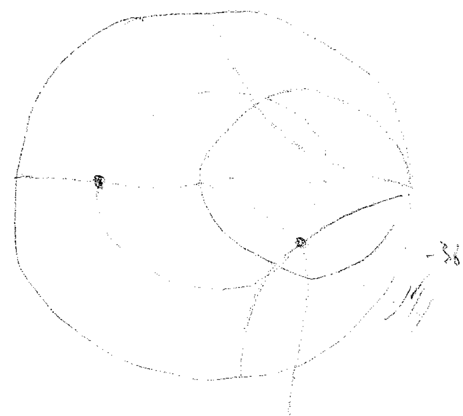
When the "short-circuit" is replaced by an **unknown load**, the measured **VSWR** on the line is **3.2** and a **voltage minimum** is detected at **39.6cm**.

Determine the **load impedance** (in rectangular form), the **reflection coefficient** of the load (in polar form), and the **frequency** of operation.

You must use and completely LABEL the Smith Chart on the following page when solving all parts of this problem (except for the frequency).

$\frac{1}{2}\lambda = 11\,cm \to \lambda = 22\,cm$





$\frac{4.4\,cm}{22\,cm/\lambda} = 0.2\lambda$ Towards load

$\lambda = c/f \to f = c/\lambda = \frac{3\times10^8}{0.22} = \boxed{1364\,MHz}$

$\bar{Z}_R = 1.7 - j1.44$

$Z_R = \bar{Z}_R \cdot Z_0 = \boxed{85 - j72}$

$\Gamma_R = \boxed{0.524 \angle -36°}$

Z_R = 85 − j72 Ω

Γ_R = 0.524 ∠ −36°

f = 1364 MHz

Do NOT Write Below This Line

1) ______ **/25** **2)** ______ **/25** **3)** ______ **/10** **4)** ______ **/15** **5)** ______ **/25** **Total)** ______ **/100**

#5

$\bar{z}_R = 1.7 - j1.44$