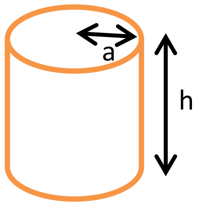
JUAS 2019 – Exercise

$\mu = \mu_0\, \mu_r$
$\mu_0 = 4\pi \cdot 10^{-7}$ Vs/(Am)
$\varepsilon = \varepsilon_0\, \varepsilon_r$
$\varepsilon_0 = 8.854 \cdot 10^{-12}$ As/(Vm)
$c_0 = 2.998 \cdot 10^{8}$ m/s

1.) Cavities



Design a pillbox cavity. The $E_{010} = TM_{010}$ mode shall resonate at f_{res} = 2.95 GHz. The aspect ratio shall be a/h = 0.5.

1. What is the radius a of the cavity?

2. What is the height h of the cavity?

3. The 3 dB bandwidth of the unloaded resonance shall be 150 kHz, how big does the unloaded Q_0 of the cavity need to be?

4. What is the maximum tolerable surface resistance ρ of the cavity walls to get Q_0 = 20 000.

5. What is the R/Q for this cavity geometry?

6. Derive the equivalent circuit parameters R, L and C for the cavity with
   Q_0 = 20 000 and R/Q = 30

7. The cavity is critically coupled to an RF power amplifier and driven by 50 W of input power on its resonant frequency. The loaded Q_L is 10 000. What is the stored energy W_{CAV} in the cavity?

8. Determine the peak gap voltage V_{gap}?

9. Operating the cavity in air, is "Kilpatrick" voltage breakdown a problem?

2.) Smith chart

Given in the table below are several impedances $\mathbf{Z_N}$ or reflection coefficients $\mathbf{\Gamma_N}$, measured at specific frequencies.
They have been normalized already with the characteristic impedance $Z_C = 50\ \Omega$ in the following way: $Z_N = Z/Z_C$

Point no.	P_1	P_2	P_3	P_4
$\mathbf{Z_N}$ or $\mathbf{\Gamma_N}$	$\mathbf{Z_N} = 1$	$\mathbf{Z_N} = 0.5 + 0.5j$	$\lvert\mathbf{\Gamma_N}\rvert = 0.45$ $arc(\mathbf{\Gamma_N}) = -117°$	$\mathbf{Z_N} = 0$
f [GHz]	3.000	2.997	3.003	0.01

Point no.	P_5	P_6	P_7	P_8
$\mathbf{Z_N}$ or $\mathbf{\Gamma_N}$	$\mathbf{Z_N} = 0.2 + 0.4j$	$\mathbf{Z_N} = 0.2 - 0.4j$	$\lvert\mathbf{\Gamma_N}\rvert = 1$ $arc(\mathbf{\Gamma_N}) = 0°$	$\lvert\mathbf{\Gamma_N}\rvert = 0.49$ $arc(\mathbf{\Gamma_N}) = 52°$
f [GHz]	2.994	3.006	-	-

1. Mark all the points in the attached smith chart (including each point no.)
   Use your compass and the rulers at the bottom of the smith chart for the polar coordinates
2. Design a matching circuit. The point P_2 in the smith chart shall be matched to $Z_C = 50\ \Omega$. Use only **one 50 Ω transmission line** and **one series capacitor.** Draw the solution in the smith chart. Numerical answers are not needed.
3. Draw a circle through the points P1 – P6. This is the result of a S_{11} measurement of a microwave cavity with a network analyser.
   What is the resonant frequency f_{res} of the cavity? (Look it up in the table)
4. What is the unloaded Q_0 of the cavity?