MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science

6.014 Electrodynamics

	Issued:	April 9, 2002
Problem Set 9	Due in Recitation:	April 17, 2002

Suggested Reading: Text: Sections 6.1, 6.3, and 8.4.

Problem 9.1

What are the Thevenin equivalent circuits for the following lossless air-filled 100-ohm TEM lines at 1 MHz?

a) An open-circuited line $7\lambda/8$ long.
b) A 50-ohm resistor at the end of a line $\lambda/8$ long
c) A voltage source $\underline{V}_o$ in series with a 100-ohm resistor at the end of a $\lambda/4$ line.

Problem 9.2

The line of Problem 9.1 is terminated with a load R. What fraction of the incident power is reflected if:

a) R = 50 ohms
b) R = -50 ohms

Problem 9.3

A 100-ohm source is to be matched to a 200-ohm load at wavelength λ.

a) Design a quarter-wave TEM transformer for a TEM line with $\varepsilon = 4\varepsilon_o$. What are the line impedance Z_o and length D?
b) Using a Smith chart, design a matching circuit that uses an inductor L in series with a 100-ohm TEM line to match a load at λ that has impedance 100 + 100j ohms. What are L and the line length D?
c) Repeat (b) for the case where the inductor is connected in parallel with the 100-ohm line. Again, what are L and the line length D?

Problem 9.4

We want to design a 10-MHz RLC resonator that utilizes a resistor R = 1 ohm and has a Q of 100.

a) What are L and C for a series resonator?
b) What are L and C for a parallel resonator?

Problem 9.5

We wish to connect a 100-ohm TEM line with a matched source to an RLC resonator so as to achieve a matched load at 10 MHz with a loaded Q of 100 ("loaded Q" means $Q = \omega/\Delta\omega$ is measured with the line and source connected).

a) Design this RLC resonator (choose R, L, C, and either a series or parallel configuration) so as to achieve an open-circuit line termination as $f \to 0$ or ∞ Hz.
b) What are the external and internal Q's (Q_E and Q_I) for your circuit?
c) If this resonator is energized and then is allowed to decay by transmitting power down the TEM line to a matched load, what is the decay rate α for the resonator voltage V; e.g., $V = V_o e^{-\alpha t}$? Note that parts (b) and (c) do not require knowledge of the specific values you chose for L and C.