MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science

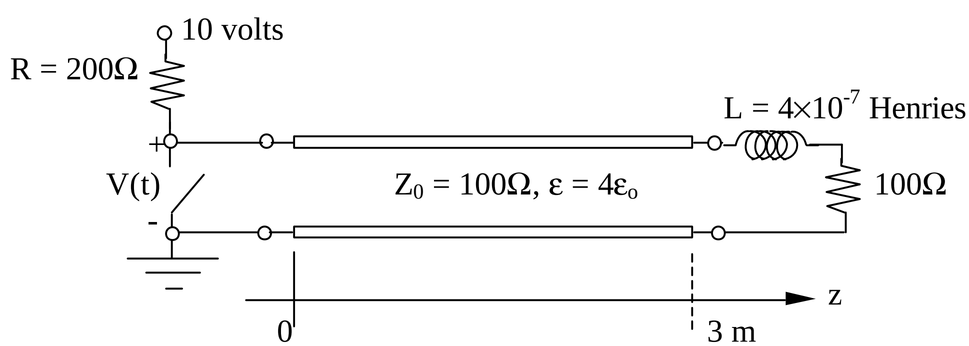
6.014 Electrodynamics

	Issued:	April 2, 2002
Problem Set 8	Due in Recitation:	April 10, 2002

Suggested Reading: Text: Sections 6.5, plus Supplementary notes for L14, R15.

Problem 8.1

A TEM control line in a certain computer has 100-ohm characteristic impedance, $\varepsilon = 4\varepsilon_o$, and length 3 cm. It is driven as illustrated. The transistor is either a perfect short circuit or a perfect open circuit.



a) The circuit is at rest for $t < 0$ with the transistor switch closed; at $t = 0$ the switch opens. Sketch and dimension the voltage v(z) on the line at $t = 10^{-8}$ seconds.

b) Sketch and dimension v(z) on the line at $t = 3\times10^{-8}$ seconds. Please indicate quantitatively any exponential time constants.

c) Repeat (b) at 5×10^{-8} seconds.

d) Sketch the voltage across the switching transistor as a function of time t. What are the maximum and asymptotic ($t \rightarrow \infty$) values of this voltage? Note that the maximum voltage is more than twice its equilibrium values that result when the switch is either on or off. Does this suggest a rule of thumb for specifying transistor breakdown voltages?

Problem 8.2

a) Repeat your answer for part (b) of Problem 8.1, but using quantitative function expressions (e.g. in terms of $u(t-t_1)$, etc.) rather than sketches.

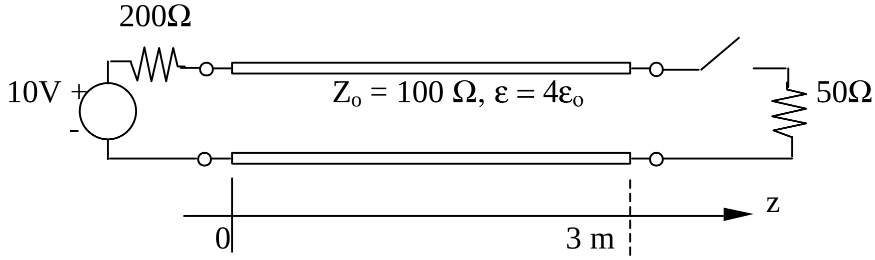
b) Repeat Part (b) of Problem 8.1 for a load consisting of only an ideal diode in series with a 5-volt battery; in equilibrium the diode is back-biased when the switch is short-circuited.

Problem 8.3

The illustrated circuit is in equilibrium for $t < 0$, and then the switch is opened.

a) Prior to opening the switch, what are the voltages and currents associated with the forward and backward moving waves on this TEM line?

b) Sketch and dimension the total voltage v(z) and current i(z) at $t = 10^{-8}$ seconds.



Problem 8.4

In certain parts of the world locusts can pose serious threats. Let's assume a single locust has a radar scattering cross-section of one square centimeter and that we have been asked to design a mobile radar for tracking swarms of these pests. If it is to fit on the back of a Jeep, it might reasonably have an antenna of diameter one meter and a peak pulse power of 1kW. Let's assume our receiver can detect a locust with received pulses of 10^{-19} Joules. We might distinguish flying insects from ground and tree clutter by their small Doppler shifts.

a) What maximum wavelength λ should we use if we wish to observe one locust at a range R of 1 km?

b) At what maximum range R could we detect a swarm of 10^5 locusts at a wavelength of 1 cm?