Solution to Practice Questions 1

ECE 3025: Electromagnetics

(1) **Short Answer Section**

(a) matched

(b) latency

(c) false

(d) short (1) open (2)

(e) open (1) short (2)

(f) decrease (1) increase (2) decrease (3)

(g) true

(h) iteration

(2) **Descriptive Answer Section**

(a) **Transmission Line Equations:**

- term circled: $V^- g\left(t + \frac{z}{v_p}\right)$
- term boxed: $\frac{V^+}{Z_0}$
- $v(0,t) = V^+ f(t) + V^- g(t)$
- $i(z,0) = \frac{V^+}{Z_0} f\left(\frac{D-z}{v_p}\right) - \frac{V^-}{Z_0} g\left(\frac{D+z}{v_p}\right)$

(b) **Continuum of Reactance:**

We should recognize this situation as our model for a transmission line with impedance:

$$Z_0 = \sqrt{\frac{L}{C}} = 100\Omega$$

A pulse enters this network and, assuming ideal, lossless components, simply bounces back and forth on the line with an amplitude of 100 V and a current of 1 A.

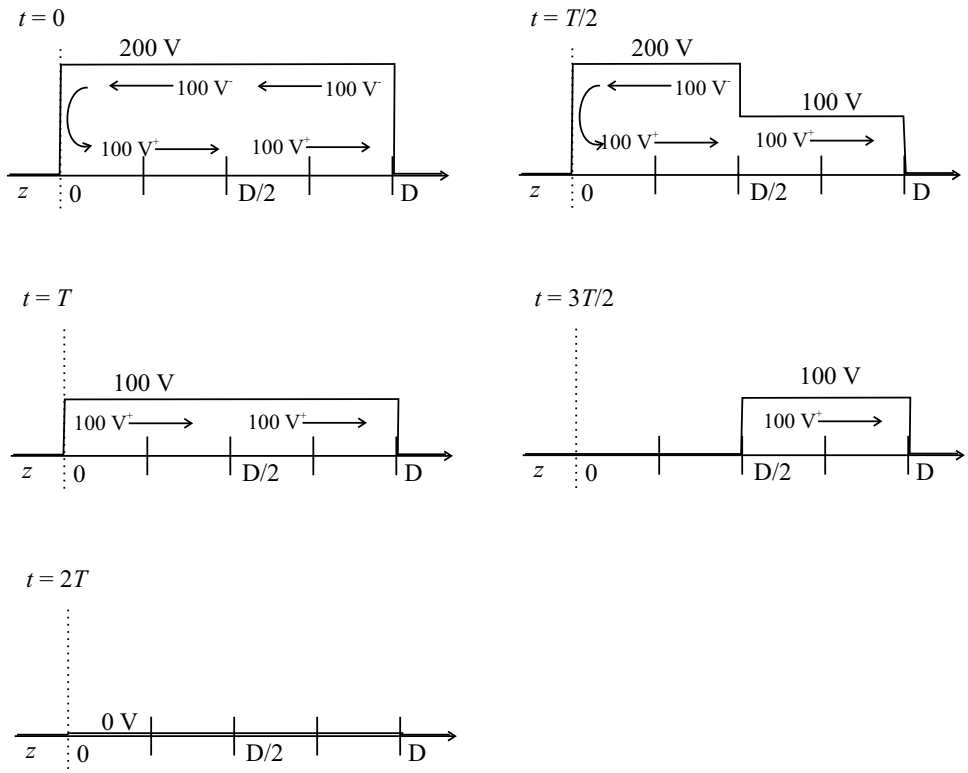
(c) **Mystery Matching Circuit:**

The inductor acts as an open circuit initially, so that the load resistance appears to be $Z_0 - R_L$ in series with R_L for a total of Z_0 resistance – a perfect match to the line! In time the inductor becomes a short circuit, removing the effects of the matching resistor; only the true load remains. This scheme only works for $R_L < Z_0$

– otherwise, the matching resistor would have to be negative.

Work-out Problem Section

(3) **Discharge of a Long Capacitor:**
When charged to 200 V, we can equivalently model this capacitor as two 100 V DC waveforms traveling forwards and backwards, each reflecting on the ends of the open-circuited line with $\Gamma = 1$. When the finger touches one end of the capacitor (say at $z = D$ on the "load" side), the reflection coefficient at that end becomes 0 due to the perfect impedance match. The voltage discharges into the finger while being fed for the first T by the existing forward 100V waveform, then by the reflected 100V backwards-propagating wave for the next T. For this configuration, $v_p = \frac{1}{\sqrt{LC}} = 10$ m/s, so the total discharge time is $2T = \frac{2D}{v_p} = 0.1$ s. Snapshots of the line voltage are shown below:



(4) **Striplines on PCB:**

a. $w_1 = w_2 = \frac{w_0 - 2h}{2}$

b. Make w_1 and w_2 different widths such that $Z_1 || Z_2$ is still matched to Z_0, while the propagation velocity on segment 2 is twice as high as segment 1.