

THE UNIVERSITY OF BRITISH COLUMBIA
Department of Electrical and Computer Engineering

ELEC 311 – Electromagnetic Fields & Waves
2025-W1

Drill Problems for
Chapter 13 – Guided Waves

The purpose of the nine drill problems from Chapter 13 is to help you master fundamental techniques used to analyze guided waves. (Problem D13.4, 13.11, 13.12 are not assigned.)

Answers should be short and to the point. It is especially critical to use sketches to explain your solution here. Clarity, conciseness, and presentation all count. Solution = Intuition (strategy) + Execution (calculation). Make both explicit.

The numerical answers below are from the text. Do you agree with them?

- D13.1 Parameters for the planar transmission line shown in Figure 13.2 are $b = 6$ mm, $d = 0.25$ mm, $t = 25$ mm, $\sigma_c = 5.5 \times 10^7$ S/m, $\epsilon' = 25$ pF/m, $\mu = \mu_0$, and $\sigma/\omega\epsilon' = 0.03$. If the operating frequency is 750 MHz, calculate: (a) α ; (b) β ; (c) Z_0 .

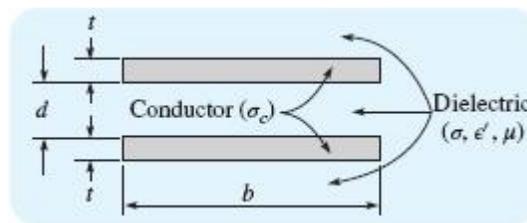


Figure 13.2 The geometry of the parallel-plate transmission line.

Answers: (a) 0.47 Np/m; (b) 26 rad/m; (c) $9.3 \angle 0.7^\circ \Omega$

- D13.2 The dimensions of a coaxial transmission line are $a = 4$ mm, $b = 17.5$ mm, and $c = 20$ mm. The conductivity of the inner and outer conductors is 2×10^7 S/m, and the dielectric properties are $\mu_r = 1$, $\epsilon_r = 3$, and $\sigma/\omega\epsilon' = 0.025$. Assume that the loss tangent is constant with frequency. Determine: (a) L , C , R , G , and Z_0 at 150 MHz; (b) L and R at 60 Hz.

Answers: (a) $0.30 \mu\text{H/m}$, 113 pF/m, $0.27 \Omega/\text{m}$, 2.7 mS/m, 51 Ω ; (b) $0.36 \mu\text{H/m}$, 1.16 m Ω/m

D13.3 The conductors of a two-wire transmission line each have a radius of 0.8 mm and a conductivity of 3×10^7 S/m. They are separated by a center-to-center distance of 0.8 cm in a medium for which $\epsilon_r' = 2.5$, $\mu_r = 1$, and $\sigma = 4 \times 10^{-9}$ S/m. If the line operates at 60 Hz, find: (a) δ ; (b) C ; (c) G ; (d) L ; (e) R .

Answers: (a) 1.2 cm; (b) 30 pF/m; (c) 5.5 nS/m; (d) 1.02 μ H/m; (e) 0.033 Ω /m

D13.5 Determine the wave angles θ_m for the first four modes ($m = 1, 2, 3, 4$) in a parallel-plate guide with $d = 2$ cm, $\epsilon_r' = 1$, and $f = 30$ GHz.

Answers: 76°; 60°; 41°; 0°

D13.6 A parallel-plate guide has plate spacing $d = 5$ mm and is filled with glass ($n = 1.45$). What is the maximum frequency at which the guide will operate in the TEM mode only?

Answers: 20.7 GHz.

D13.7 A parallel-plate guide having $d = 1$ cm is filled with air. Find the cutoff wavelength for the $m = 2$ mode (TE or TM).

Answer: 1 cm.

D13.8 Determine the group velocity of the $m = 1$ (TE or TM) mode in an air-filled parallel-plate guide with $d = 0.5$ cm at $f =$ (a) 30 GHz, (b) 60 GHz, and (c) 100 GHz.

Answers: (a) 0; (b) 2.6×10^8 m/s; (c) 2.9×10^8 m/s

D13.9 A TE mode in a parallel-plate guide is observed to have three maxima in its electric field pattern between $x = 0$ and $x = d$. What is the value of m ?

Answer: 3

D13.10 Specify the minimum width, a , and the maximum height, b , of an air-filled rectangular guide so that it will operate in a single mode over the frequency range $15 \text{ GHz} < f < 20 \text{ GHz}$.

Answers: 1 cm; 0.75 cm