Practice Test for ECE 3065: Electromagnetic Applications

Note: This practice test was constructed from old or leftover test questions. This is meant for practice and, since no attempt was made to regulate the cumulative time for answering all the questions, taking the "practice test" may require more time than taking the actual in-class test. The in-class test includes all necessary equations in either the problems statements or on attached formula sheets.

1. **Short Answer Section**

(a) ________________

True or False: In a rectangular waveguide, the TM_{02} mode is a valid mode of wave propagation.

(b) ________________

True or False: The phase velocity of a wave can exceed the speed of light in a vacuum.

(c) ________________

Only certain types of solutions, called *modes*, satisfy the wave equations within a waveguide due to the [*Answer*] conditions imposed on the fields at the surfaces of the waveguides.

(d) ________________

For a given frequency, what type of transmission-line resonator results in the smallest possible resonator circuit.

(e) ________________ (1) ________________ (2)

Two example applications that use high-Q resonators are [*Answer 1*] and [*Answer 2*].

(f) ________________ (1) ________________ (2) ________________ (3)

Name 3 different types of resonators studied in this class, from highest-to-lowest typical Q-factors.

(g) ________________

In addition to modal cut-off, propagation in a *dielectric* waveguide is also limited to launch angles that exceed the [*Answer*] angle.

(h) ________________

In a metallic waveguide, the tangential electric fields on the surface of the conductor must equal [*Answer*].

(i) ______________ (1) ______________ (2)

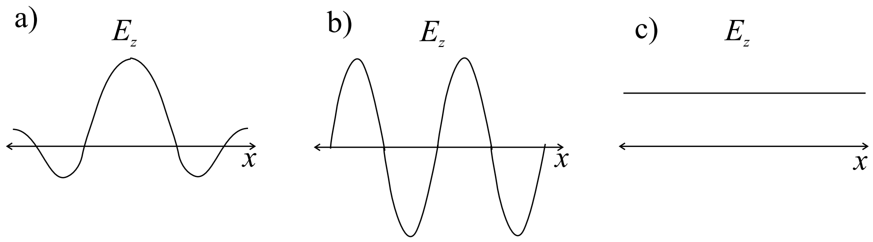
A resonator with a high Q-factor implies that the device can store energy with low *Answer 1*. It also implies that the *Answer 2* is very small relative to the center frequency.

2. **Descriptive Answer Section**

Write a **concise** answer to each question in the spaces provided beneath each problem statement. **Note:** Correct answers that are extremely verbose will be penalized.

(a) **Microwave Oven:** A microwave oven is essentially a rectangular cavity resonator the operates at 2.4 GHz. You heat a plate full of food in the microwave that does not have a carousel for rotating the food while cooking. Based on your knowledge of modal field analysis, explain why some portions of the food are very hot and others are still cool.

(b) **Waveguide Shapes:** You measure the z-component of electric field distribution across a portion of the horizontal cross section of 3 different metallic waveguides. The results are sketched below.



i. What type of waveguide is case (a)?

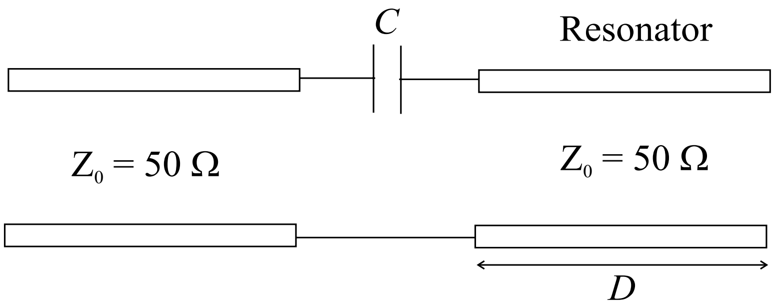
ii. What type of waveguide is case (b)?

iii. What type of waveguide is case (c)?

iv. If the direction of propagation is z, then what type of modes are all of these sketches?

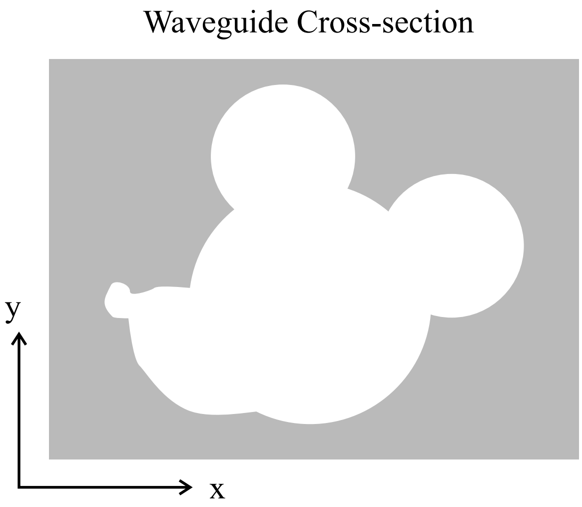
3. **Transmission Line Resonator:**

Calculate the length D, coupling capacitance C, and loaded Q-factor of the open circuit stripline resonator shown below. Your target frequency is 2.5 GHz and the velocity of propagation is 2.0×10^8 m/s. The attenuation constant of the line is $\alpha = 0.25$ Np/m.



4. **Nonstandard Waveguide:**

You are given a 1m-long air-filled waveguide with Mickey Mouse-shaped cross-section shown below. You have some test and measurement equipment that measures the transit time of a wave through a device. You perform this measurement at 4 GHz and find that no waves propagate in the waveguide. You repeat this measurement at 6 GHz and find that a signal takes 6.68 ns to propagate through the waveguide. Again you measure transit time at 8 GHz and find that the measurement is indeterminate since there are multiple modes present in the waveguide. Answer the following questions based on this scenario.



(a) What is the cut-off frequency of the dominant mode for this waveguide?

(b) Make a rough estimate as to how fast the next-highest mode would propagate if excited at 14 GHz?

(c) The waveguide is suddenly pumped full of a dielectric with permittivity of $\epsilon_r = 9$. If you repeated the transit time measurements at 4, 6, and 8 GHz, what would you measure and why?