USPAS Graduate Accelerator Physics Homework 7

Due date: Wednesday February 3, 2021

1 Mode $\mathbf{TM}_{010}$

(10 points) Why is the TM_{010} mode usually preferred in an RF cavity?

2 Kilpatrick criterion

(10 points) The Kilpatrick criterion

$$f \;=\; 1.64\; E_k^2\; \exp(-8.5/E_k) \tag{2.1}$$

is an empirical equation from the 1950s that predicts the relation between frequency f (in MHz) and electrical field E_k (in MV/m) on a room-temperature copper surface at the limit of electrical breakdown. Higher frequencies support higher gradients. Contemporary vacuum systems allow the Kilpatrick limit E_k to be exceeded by bravery factors as large as 2.

If the maximum surface field on the walls of a single-cell pill box cavity is $1.8E_k$, then how many cavities are required to accelerate beam at 5 MeV per turn when the frequency is 200 MHz, 400 MHz, and 800 MHz?