USPAS Accelerator Physics
Problem Set 8 - 60 pts.

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Problem 1

P024 Pillbox Cavitiy 30 pts.

Consider a pillbox cavity of radius $r_c = 75/2$ cm and axial length $\ell = 50$ cm

a) 2 pts: What is the resonant frequency of the fundamental TM_{010} mode?

b) 2 pts: What is the resonant frequency of the next highest TM_{011} mode?

c) 6 pts: What value of β will have a transit-time factor, $T = 1/2$ for this cavity operating at the fundamental frequency? Use the single-gap transit-time factor derived in class. Feel free to use a numerical root finder or estimate from a plot. β should be greater than this value for $T > 1/2$.

d) 5 pts: Explain how the cavity operating at the fundamental frequency might be modified to increase the acceleration efficiency [larger T for given β found in part (c]. Qualitative only.

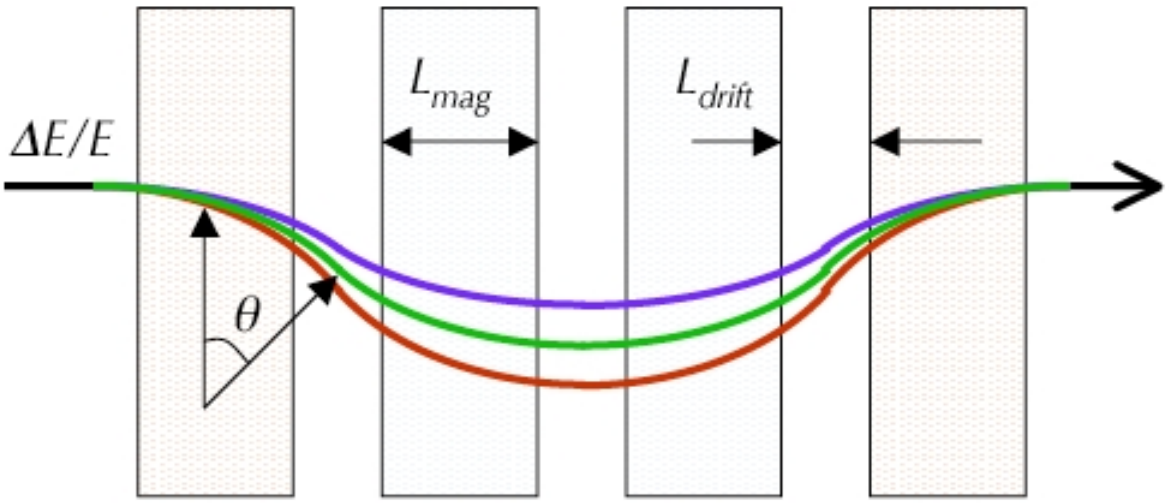
e) 15 pts: For the cavity operating at the fundamental frequency, assume an RF voltage $V_0 = E_0\ell = 500$ kV and assume the cavity is made of copper with conductivity of $1/\sigma = 1.7 \times 10^{-8}$ Ωm, calculate:

U = stored EM energy
R_{surf} = RF surface resistance
$\langle P_{\mathrm{loss}} \rangle_{\mathrm{rf}}$ = average power lost over RF period
Q = Quality factor
R_s = shunt impedance

Use formulas derived in the class notes.

Problem 2

P043 Chicane 10 pts.



A "chicane" consists of four identical sector dipoles as shown above. Each dipole has axial length L_{mag} and bends the beam by angle θ_B. The drift space between two adjacent dipoles is L_{drift}. Show for the chicane lattice that:

$$R_{56} = \frac{\mathrm{d}z}{\mathrm{d}\delta} \approx -2\theta_B^2 \left(L_{\text{drift}} + \frac{2}{3} L_{\text{mag}} \right)$$

Problem 3

P044 LCLS Parameters 20 pts.

Consider the parameters of LCLS:

Parameters	Values
Beam energy	14.35 GeV
Peak current	3500 A
Pulse length	230 fs
FEL parameter	$5 \times 10^{-}4$
RMS angular divergence	1.7 μrad
Undulator wavelength	3 cm
Undulator parameters K	3.7

Calculate the following:

1) Radiation wavelength, λ_r.

2) Bunch change of each electron bunch.

3) Approximate number of electrons in one micro-bunch.

4) 1-D gain length, L_{1D}.

5) Approximate undulator axial length.

6) Approximate peak radiation power.

7) The width of the frequency spectrum at saturation.