

Homework Assignment #1

Due by online submission Monday 1/25/2013 (Tuesday at 9am)

1. You're standing on a big smooth hillside. Directly North the hill climbs up quite steeply, rising 20 cm for every step you take. Directly East the hill climbs gently, rising only 1 cm for every step you take. If you want to be 10 steps further north than you currently are, how far east do you have to walk in order to stay at the same altitude?
2. You have made a new three terminal device. Terminal A is grounded. Terminal B is the input. Terminal C is the output. The output current I_c is given by $I_c = f(V_{ba}, V_{ca})$. You measure an output current I_C at a certain bias point (V_{BA}, V_{CA}) .
 - a. Assuming that f is a smooth function (its derivatives exist), write an exact expression for how the current will vary for small changes to the input and output voltages around that bias point. Write those changes as i_b , v_b and v_c .
 - b. Simplify your answer to the best linear approximation to f at the bias point (a plane through (V_{BA}, V_{CA}, I_C)).
 - c. If you don't allow the output current to vary (you keep it fixed at I_C so $i_c=0$), write an equation for the output voltage as a function of the input voltage.
 - d. Write your answer to the problem 1 using this same formalism.
 - e. What is the gain of a common emitter amplifier with a current source load, using this same formalism?
3. You live in an area with a lot of gold mines. You have developed a model that says that the amount of gold G that you get from a mine as a function of the total hours worked H is given by $G(H) = G_0 ((H/T)^2 - (H/T)^3)$ from the time that people first start excavating the mine (when $H=0$) until the time that all of the gold is gone, $H=2T/3$. If you only get to work for one hour in the mine, does it matter if you work at the beginning, vs. the middle or the end? When should you work to mine the most gold? How much will you get? If $T=1000$ years, and you start working at $H=T/2$ and work for a year, does your gold mining rate change much from month to month?
4. Graph the magnitude of the impedance of the following elements and circuits by hand. Use a log/log scale, with the frequency axis varying from 1 to 10^{11} rad/sec, and impedance axis varying from 1 Ω to 10 G Ω .
 - a. Resistors of magnitude 1k Ω , 1M Ω , 1G Ω and capacitors of 1 uF, 1nF, and 1pF; and inductors of magnitude 1mH, 1uH, 1nH (all 9 of these components should be on the same plot)
 - b. The series combination of 10k Ω and 10pF
 - c. The parallel combination of 10k Ω and 10pF
 - d. The series combination of 10 Ω and 10nH (real inductors always have series resistance)
 - e. The parallel combination of the previous real inductor and 1pF (roughly what an LC tank in your cell phone looks like)
5. [ee240A] Using the datasheet from the [vacuum tube](#) (6 pages, 2.5 MB) Estimate g_m , r_o , and the maximum possible gain for the tube used with a constant current source bias of 100mA on the plate and -75 V bias on the grid. In a tube, the plate is sort of like the drain or collector of a transistor, and the grid is sort of like the gate or base. You will have to estimate some derivatives from the graph for this problem.