Physics 3200Y: Assignment V

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January 7, 2026

Problem 1. Griffiths 4.13

Solution 1.

Problem 2. In lab, before Christmas, you measured the capacitance of a ferroelectric capacitor. This question asks you to make sense of your data.

(a) Consider a parallel-plate capacitor of thickness d and area A. The area between the capacitor plates is filled with a ferroelectric, with polarization

$$P = \pm P_s + \epsilon_0 \chi E,$$

where P_s is the magnitude of the polarization when the electric field is zero, χ is the dielectric susceptibility that tells you how the polarization changes when a field E is applied, and E is the electric field in the capacitor. The ferroelectric polarization contains a factor $\pm$ to account for the two possible states, one with polarization pointing up and one with polarization pointing down.

i Find the electric field E and the charge density σ on the plates when the voltage across the capacitor is V. Note that your answer will contain $\pm P_s$.

ii ketch a graph of σ vs. V. Note that

- there are two branches, corresponding to the two signs of Ps;
- the direction of P_s will flip when the internal electric field exceeds the so-called "coercive field" E_C. Your graph should look something like this one: https://en.wikipedia.org/wiki/ Ferroelectricity#/media/File:Ferroelectric_polarisation_DE.svg.

Be sure to label the coercive fields on your graph and explain (in terms of the model introduced here) the arrows that are shown in the figure I've linked to above.

(b) In a Sawyer-Tower circuit, the total charge that flows onto the unknown "sample" capacitor (i.e. the ferroelectric capacitor) is equal to the charge that flows onto the reference capacitor, $Q = C_r V_r$. Furthermore, the voltage across the sample is $V_s = V - V_r \approx V$. A graph of V_r vs. V should therefore look like your sketch, assuming the capacitor really is ferroelectric. Make such a plot and try to interpret your data in terms of the model in part (a). How does your data agree or disagree with the model. I know that you measured your data at multiple frequencies, so choose one or two frequencies that illustrate the typical behaviour you observed.

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i $Q = CV =$

ii Sketch a graph of σ vs. V. Note that

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