Physics 217 Problem Set #4

Due Tuesday, 23 September 2025, in Box.

Submit your solutions by uploading an electronic, or at least legibly-scanned, pdf copy to your personal PHYS 217 Box folder. Note that cell-phone pictures are not usually legible, nor produced in pdf.

Please follow this file-naming convention: **`boxusername_HW#_Phys217.pdf`**, where **`boxusername`** is the name associated with your PHYS 217 Box folder and **#** is the number of the homework assignment. Please also submit your work as **one** pdf file.

Submission, completeness, and correctness will be noted for problems with numbers not bearing asterisks and will add to your Class-Participation grade. You will start these problems in Workshop. You may collaborate with classmates on their solution, inside or outside of class. List in your solutions the names of the classmates with whom you collaborated.

Problems marked with an asterisk will be graded in detail and comprise part of your Homework grade. These are solo efforts; you may not collaborate with classmates on their solution.

1-5 Griffiths problems 2.40, 2.42, 2.43, 3.4,, and 3.5.

6*. We inflate a lightweight, spherical conductive balloon not by gas pressure, but by placing electric charge on its surface. The balloon is not tied off; the gas pressure is 1 atmosphere, inside and out. It reaches a radius of 5 cm before it starts to draw sparks from its surroundings, which happens when the maximum electric field reaches the ionization-breakdown strength of air: $E \approx 100$ statvolt esu^{-1} (cgs) or 3×10^{6} Nt coul^{-1} (SI).

   a. What is the charge q and the electric potential V on the balloon's surface?

   b. Without electric charge, what additional gas pressure P, in atmospheres, would inflate the balloon to the same radius?

7*. A small round, uniform asteroid has mass M and radius R. We have a high-energy proton beam, and in the name of science we use it to bombard the asteroid with protons, gradually giving it a relatively large, uniform charge density. How many protons N does the proton beam need to deposit to make the asteroid explode? Calculate N for a typical small rocky asteroid: mass 8.4×10^{18} gm, $R = 10$ km.

8.* Two infinite, parallel, conducting plates, separated by distance D, have potentials 0 and V_0. Between them is a space charge region, with density $\rho = \rho_0 x/D$, and where x is the distance from the zero-potential plate. The electric field is negligible elsewhere. Calculate $V(x)$, $E(x)$, and the surface charge densities $\sigma(0)$ and $\sigma(D)$ on the plates.