Principles of Physics II (PHY 112)
Spring 2004

Exam 2

Question 1 (4 points) What can you say about the electric field inside a perfect conductor? What can you say about the electric potential inside a perfect conductor? Why is it so?

Question 2 (4 points) You have two capacitors: one with capacitance 6μF and the other with capacitance 18μF. If you put a certain amount of positive charge on one plate of each capacitor, and an equal and opposite amount of negative charge on the other plate of each capacitor, which capacitor will store more energy? Explain how you know.

Question 3 (4 points) Consider a uniformily charged cylinder with radius R and infinitely long. It has a uniform volume charge density of ρ. In order to use Gauss's Law to find the electric field produced by this charge distribution, we need to be able to write an expression for the electric flux through a Gaussian surface, and we also need to be able to write an expression for the charge enclosed by the Gaussian surface. Imagine a cylindrical Gaussian surface with radius r and length L, whose axis of symmetry coincides with that of the charge.

1. If $r < R$, write expressions for the flux through the Gaussian surface and the charge enclosed by the Gaussian surface.

2. If $r > R$, write expressions for the flux through the Gaussian surface and the charge enclosed by the Gaussian surface.

Question 4 (4 points) Consider a parallel-plate capacitor in which one plate is located on the plane $x = 0$ cm and the other plate is located on the plane $x = 3$ cm. The plate at $x = 3$ cm is positively charged, and the other plate is negatively charged. Sketch a graph of the electric potential as a function of x from $x = -3$ cm to $x = 6$ cm. Also sketch a graph of the x-component of electric field as a function of x from $x = -3$ cm to $x = 6$ cm.

Problem 1 (8 points) Find the electric potential energy of a proton and an electron that are a distance of 10^{-10} m apart.

Problem 2 (8 points) A 5 nC charge is located at $\mathbf{r} = (-1 \text{ m})\hat{\mathbf{i}} - (1 \text{ m})\hat{\mathbf{j}}$, and a -10 nC charge is located at $(6 \text{ m})\hat{\mathbf{i}} - (8 \text{ m})\hat{\mathbf{j}}$. What are the x- and y-components of the electric field produced by these two charges at $\mathbf{r} = (2 \text{ m})\hat{\mathbf{i}} - (5 \text{ m})\hat{\mathbf{j}}$?

Problem 3 (8 points) Two flat circular metal plates, each with radius 0.5 m, are separated by 1 mm. One plate has a charge of 5 nC on it and the other has an equal and opposite charge. If the electric potential at the center of the positive plate (the plate with the positive charge) is 4.0 V, what is the electric potential at a spot precisely between the two plates (equidistant from the positive and negative plates)?