Physics 158 Electric Fields Problem Bank

Problem 1

Created by Tyler Wilson 2023
A 16 cm long wire of charge $Q = 40\,\mu$C is bent into a square.

a) Find the electric field strength 20 cm vertically above the center of the square.

A point charge of mass $m = 100\,$g and charge $5\,\mu$C is now placed 20 cm above the center of the square.

b) Find the magnitude and direction of the force acting on the point charge initially.

c) Plot the acceleration of the point charge as a function of it's height above the center of the square.

Solution:

Problem 2

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An insulating sphere of radius 5 m contains a uniform charge density of $10\,\text{C/m}^3$. A hole of radius 1 m is drilled all the way through the sphere.

a) Find the electric field at the center of the sphere

b) Find the potential at the center of the sphere

c) Find the electric field at a point 6 m away from the sphere, directly above where the hole was drilled.

d) How might you compute the electric field at any point inside the object?

Problem 3

Created by Tyler Wilson 2023
The potential above some charged Gaussian surface is given by the equation

$$V = \frac{k\sigma}{3y} \text{ Volts}$$

a) What is the equation for the electric field?

b) If $\sigma = 6\,\mu$C, find the electric field strength and direction at $y = 2\,$m.

c) What can you say about the electric field in the x-direction?

Hint:

$$\vec{E} = -\frac{\partial V}{\partial x}\hat{i} - \frac{\partial V}{\partial y}\hat{j} - \frac{\partial V}{\partial z}\hat{k}$$

Solution:

a) The electric field is the negative gradient of the potential. This was defined in the hint above. The electric field would then be

$$\vec{E} = -\frac{\partial}{\partial y}\left(\frac{k\sigma}{3y}\right)\hat{j} = \boxed{\frac{k\sigma}{3y^2}\hat{j}}$$

b) Plugging in these values we would get

$$\vec{E}(y=2) = \frac{k(6\cdot 10^{-6})}{3(2)^2}\hat{j} = \boxed{4495\hat{j}\,\mathrm{N/C}}$$

c)

$$\vec{E}_x = -\frac{\partial}{\partial x}\left(\frac{k\sigma}{3y}\right) = 0$$

Therefore, the electric field in the x-direction is 0.

Problem 4

Created by Tyler Wilson 2023
A rectangular box has dimensions 2m by 4m by 8m and contains a uniform surface charge of $336\,\mu\mathrm{C/m^2}$. One corner of the box (corner A) contains a point charge of $-3\,\mu\mathrm{C}$. Find the electric field 20 m away from corner A.

Problem 5

Created by Tyler Wilson 2023
A parallel plate capacitor is hooked up to a battery in series. At time t, a dielectric is inserted into the capacitor and the volatge source is doubled. If the charge on the capacitor remains the same, find the dielectric constant.

Problem 6

Created by Tyler Wilson 2023
A resistor ($R = 2\,\Omega$) and a capacitor ($C = 16\,\mu\mathrm{F}$) are connected in parallel to a 10 V battery. If a dielectric of $\kappa = 4$ is inserted into the capacitor, what is the new current flowing through the resistor?