

# Physics 158 Electric Fields Problem Bank

## Problem 1

*Created by Tyler Wilson 2023*

A 16 cm long wire of charge  $Q = 40 \mu\text{C}$  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  $m = 100 \text{ g}$  and charge  $5 \mu\text{C}$  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:**

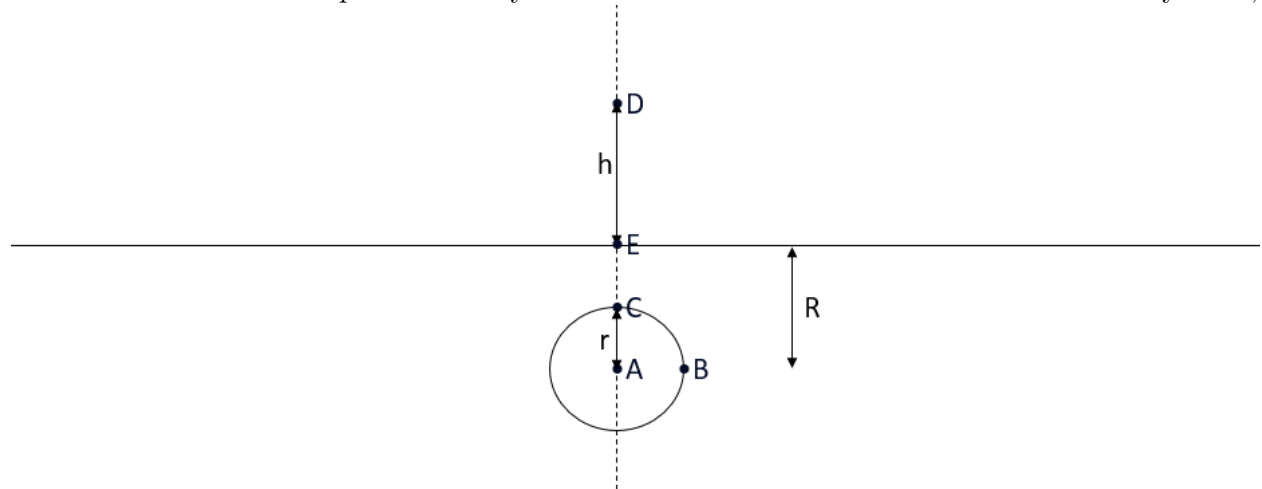
## Problem 2

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An insulating cylinder of radius  $R = 5 \text{ cm}$  and effectively infinite length contains a uniform charge density of  $10 \text{ C/m}^3$ .

- a) Find the electric field everywhere in space

If there is now a hollow spherical cavity of radius  $r = 1 \text{ cm}$  located at the center of the cylinder,



- b) Find the electric field at the center of the sphere at point A.
- c) Find the electric field just outside the sphere at point B.
- d) Find the electric field just outside the sphere at point C.
- e) If  $h = 10\text{ cm}$ , find the electric field outside both objects at point D.

If the potential at the point  $E$  is  $0\text{V}$ ,

- f) What is the potential at point A?

### Problem 3

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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  $\sigma = 6\text{ }\mu\text{C}$ , find the electric field strength and direction at  $y = 2\text{ m}$ .
- 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

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

- 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

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A rectangular box has dimensions 2m by 4m by 8m and contains a uniform surface charge of  $336\ \mu\text{C}/\text{m}^2$ . One corner of the box (corner A) contains a point charge of  $-3\ \mu\text{C}$ . 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 voltage source is doubled. If the charge on the capacitor remains the same, find the dielectric constant.

#### Problem 6

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A resistor ( $R = 2\ \Omega$ ) and a capacitor ( $C = 16\ \mu\text{F}$ ) 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?