

# F IIQ – Anotações: Campo Elétrico & Potencial

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27 de maio de 2023

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# 1 The Electric Field I: Discrete Charge Distributions

## 1.1 Coulomb's Constant

$$k = 8.99 \text{ N m}^2/\text{C}^2$$

## 1.2 Coulomb's Law

$$\vec{F} = \frac{k q_1 q_2}{r_{1,2}^2} \hat{r}_{1,2}$$

## 1.3 Electric Field

$$\vec{E} = \frac{\vec{F}}{q_0} = \frac{k q}{r^2} \hat{r}$$

## 1.4 Dipole

$$\begin{aligned} \vec{p} &= q \vec{L}_{(- \rightarrow +)} & \vec{\tau} &= \vec{p} \times \vec{E} \\ U &= -\vec{p} \cdot \vec{E} + U_0 \end{aligned}$$

## 2 The Electric Field II: Continuous Charge Distributions

### 2.1 Fluxo Elétrico

$$\phi = \lim_{\Delta A_i \rightarrow 0} \sum_i \vec{E}_i \cdot \hat{n} \Delta A_i = \int_S \vec{E} \cdot \hat{n} dA$$

### 2.2 Electric Constant (Permissivity of Free Space)

$$\epsilon_0 = (4 \pi k)^{-1} = 8.85 * 10^{-12} \text{ C}^2/\text{N m}^2$$

### 2.3 Gauss's Law

$$\phi_{net} = \oint_S \vec{E} \cdot \hat{n} dA = Q_{inside}/\epsilon_0$$

### 2.4 Discontinuity of $E_n$

$$E_{n+} - E_{n-} = \sigma/\epsilon_0$$

### 2.5 $\vec{E}$ just outside a Conductor

$$E = \sigma/\epsilon_0$$

Acts like an infinite plane surface

## Electric Fields for Selected Uniform Charge Distributions

### 2.6 Of a **line** charge of infinite length

$$\vec{E} = 2 k \lambda \hat{r}/R$$

### 2.7 On the axis of a charged **ring**

$$\vec{E} = k Q z (z^2 + a^2)^{-3/2} \hat{z}$$

### 2.8 On the axis of a charged **disk**

$$\vec{E} = \frac{\text{sign}(z) \sigma \hat{z}}{2 \epsilon_0} \left( 1 - (1 + R^2/z^2)^{-1} \right)$$

### 2.9 Of a charged **infinite plane**

$$\vec{E} = \text{sign}(z) \sigma \hat{z} / 2 \epsilon_0$$

### 2.10 Of a charged thin **spherical shell**

$$\vec{E} = \begin{cases} k Q \hat{r}/r & r > 0 \\ 0 & r < 0 \end{cases}$$

# 3 Electric Potential

## 3.1 Units and Constants

$V$ and $\Delta V$	$1\text{ V} = 1\text{ J/C}$
Electric Field	$1\text{ N/C} = 1\text{ V/m}$
Electron volt	$1\text{ eV} = 160.22 * 10^{-21}\text{ C V} = 160.22 * 10^{-21}\text{ J}$
Dielectric Strength	$\max E \approx 3.00 * 10^6\text{ MV/m}$

## 3.2 Potential Energy of Two Point Charges

$$U = q_0 V = k q_0 q / r$$

## Potential Functions

### 3.3 On the axis of a uniformly charged ring

$$V = \frac{k Q}{\sqrt{z^2 + a^2}}$$

### 3.4 On the axis of a uniformly charged disk

$$V = 2 \pi k \sigma |z| \left( \sqrt{1 + R^2/z^2} - 1 \right)$$

### 3.5 For an infinite plane of charge

$$V = V_0 - 2 \pi k \sigma |x|$$

### 3.6 For a spherical shell of charge

$$V = \begin{cases} k Q / r & r \geq R \\ k Q / R & r \leq R \end{cases}$$

### 3.7 For an infinite line of charge

$$V = 2 k \lambda \ln \frac{R_{ref}}{R}$$

## Electrostatic Potential Energy

### 3.8 Of point charges

$$U = \frac{1}{2} \sum_{i=1}^n q_i V_i$$

### 3.9 Of a conductor with charge Q at potential V

$$U = Q V / 2$$

### 3.10 Of a system of conductors

$$U = \frac{1}{2} \sum_{i=1}^n Q_i V_i$$