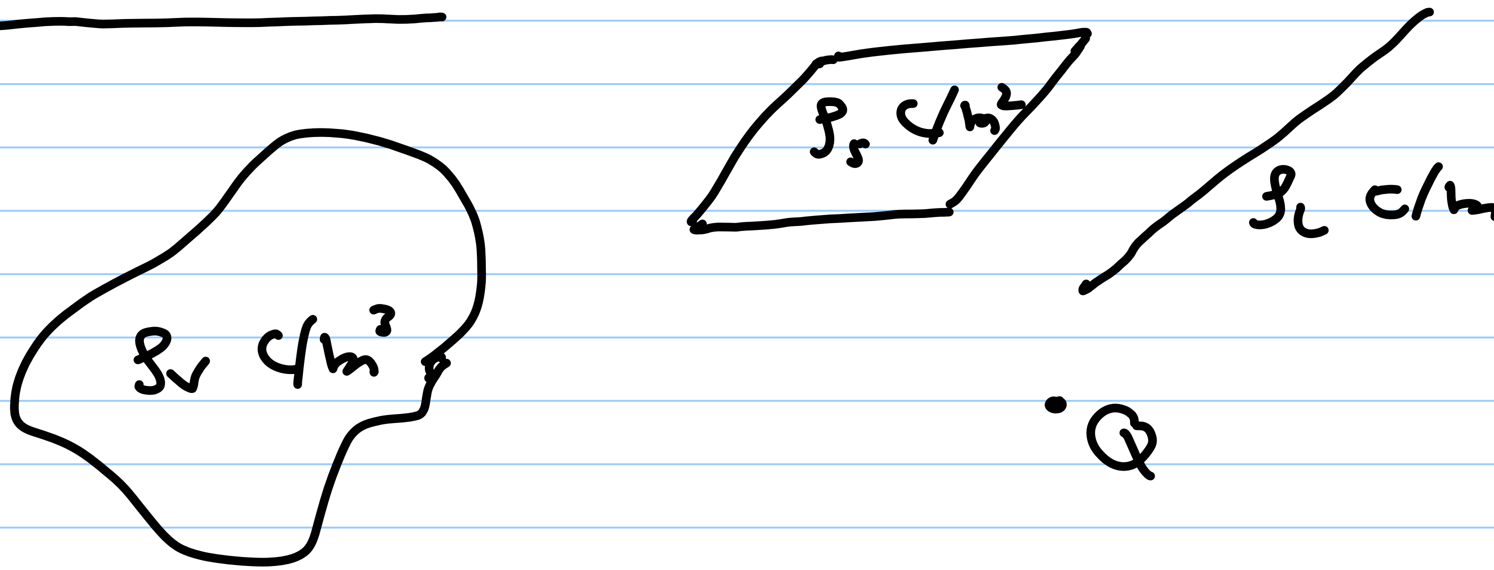
Lecture 1

From chapter 4, sections 4.1 – 4.4

Solve 4.2, 4.3, 4.6, 4.7, 4.8, 4.11

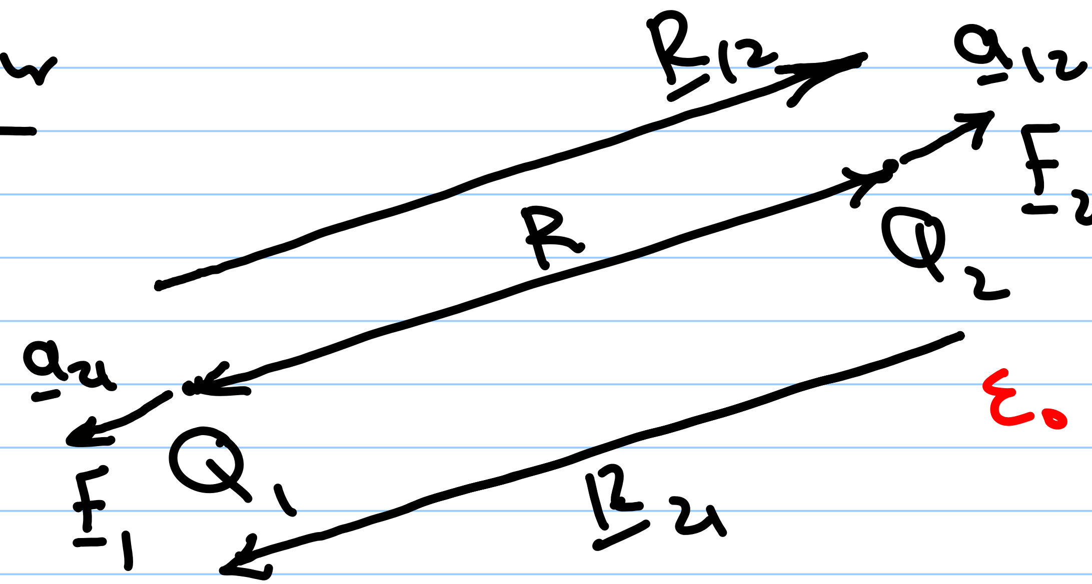
Solve All practice exercises

Electrostatics



* For any static distribution of charges, find $\underline{E}(\underline{r})$, for any $\underline{r}$
* Note that $\underline{E}$ is not a function of time

Coulomb's Law



$$\underline{F}_1 = \frac{Q_1 Q_2}{4\pi\varepsilon_0 R^2}\underline{a}_{21} = \frac{Q_1 Q_2}{4\pi\varepsilon_0 R^3}\underline{R}_{21}$$

$$\underline{F}_2 = \frac{Q_2 Q_1}{4\pi\varepsilon_0 R^2}\underline{a}_{12} = \frac{Q_1 Q_2}{4\pi\varepsilon_0 R^3}\underline{R}_{12}$$

$$\underline{F}_2 = -\underline{F}_1$$

Electric Field

* If $Q_2 = 1\,C$, we have

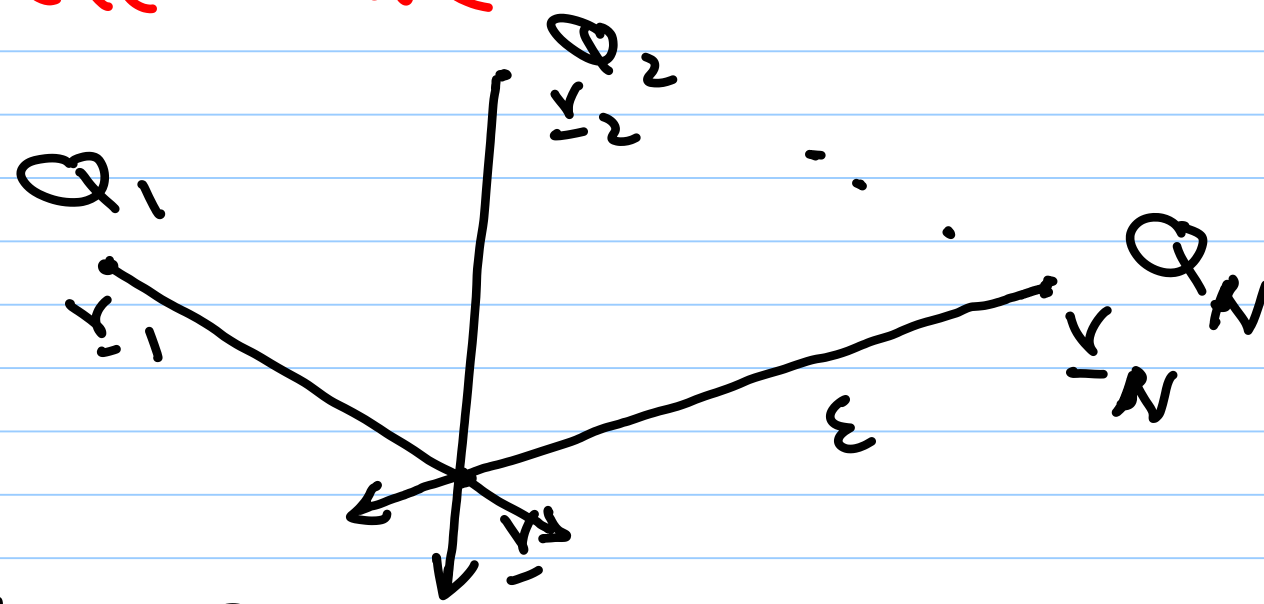
$$\underline{E} = \frac{Q_1}{4\pi\varepsilon_0 R^2}\,\underline{a}_{12} = \frac{Q_1}{4\pi\varepsilon_0 R^3}\,\underline{R}_{12}$$

* The electric field at position $\underline{r}$ due to a charge Q at location $\underline{r}'$ is

$$\underline{E}(\underline{r}) = \frac{Q}{4\pi\varepsilon_0 \|\underline{r}-\underline{r}'\|^3}(\underline{r}-\underline{r}') \quad V/m$$

Superposition

* **Discrete Case**

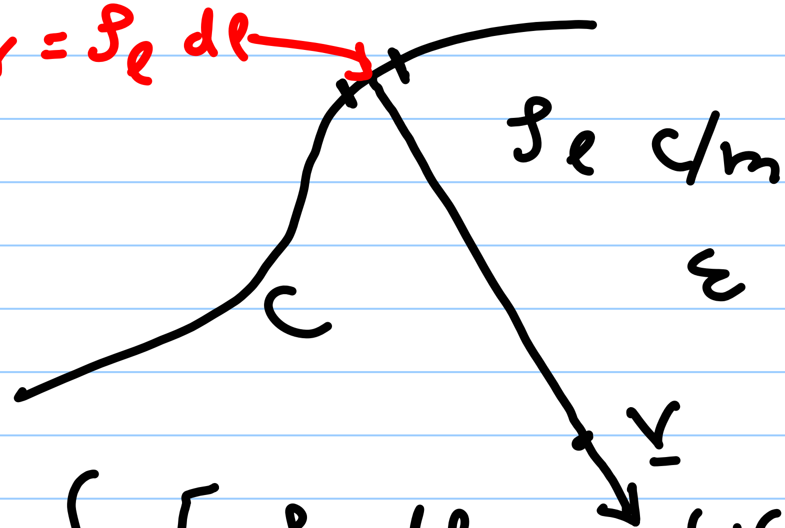


$$E(\underline{r}) = \sum_{i=1}^{N} \frac{Q_i}{4\pi\varepsilon \|\underline{r} - \underline{r}_i\|^3} (\underline{r} - \underline{r}_i)$$

Superposition

*** Linear charge case**

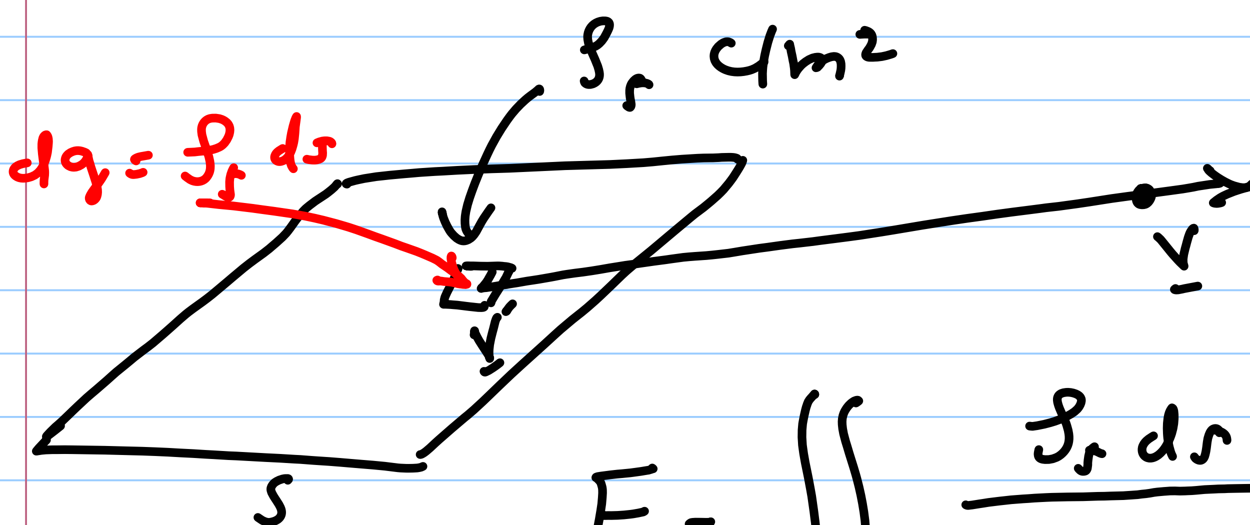
$dq = \rho_\ell \, d\ell$



$$E(\underline{r}) = \int_C \left[\frac{\rho_\ell \, d\ell}{4\pi\varepsilon \|\underline{r} - \underline{r}'\|^3} (\underline{r} - \underline{r}') \right]$$

Superposition

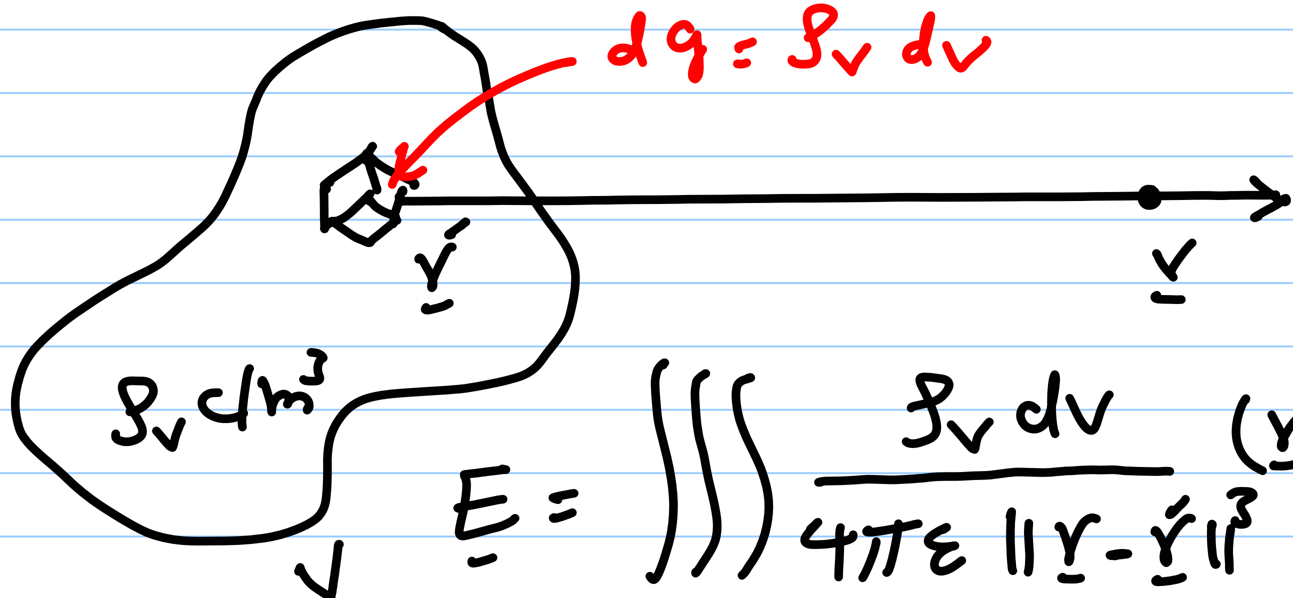
*Surface Charge Case



$$\underline{E} = \iint_S \frac{\rho_s \, ds}{4\pi\varepsilon \|\underline{r} - \underline{r}'\|^3} (\underline{r} - \underline{r}')$$

Superposition

***Volume Charge Case**



$$\underline{E} = \iiint_V \frac{\rho_v \, dv}{4\pi\varepsilon \|\underline{r}-\underline{r}'\|^3}(\underline{r}-\underline{r}')$$

Electric Flux

* $\underline{D} = \varepsilon \underline{E}$ is the electric displacement vector (C/m^2)
* The electric flux out of a surface is given by

$$\Psi = \iint_S \underline{D} \cdot d\underline{s} \quad \text{Coulomb}$$

* $\underline{D}$ is independent of dielectric type