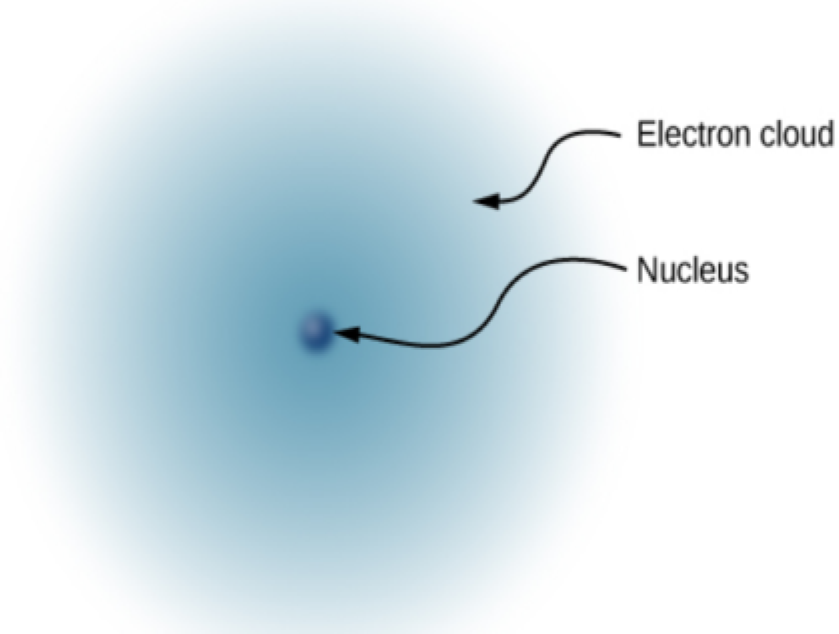
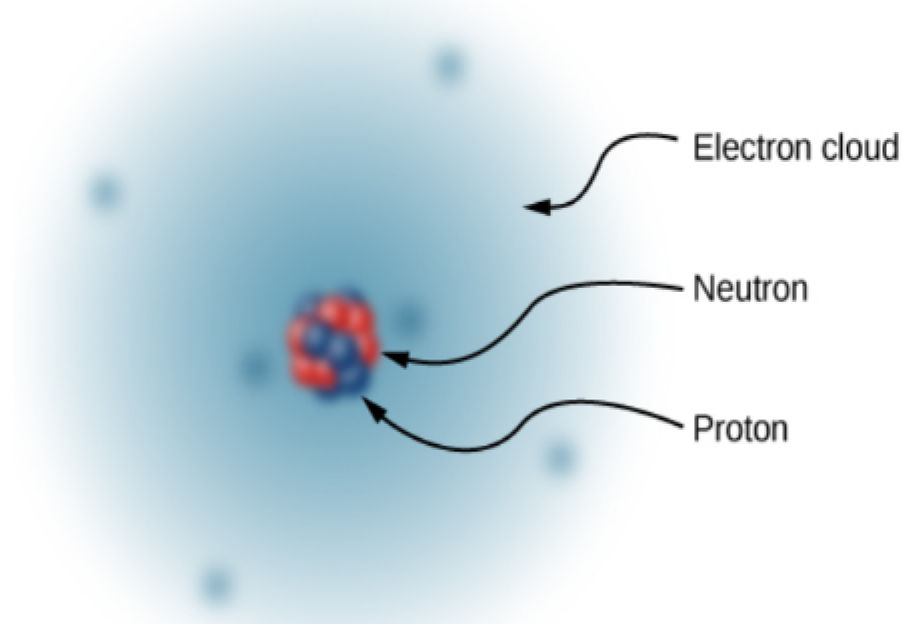
Rafhleðslur og kraftar



H - atóm



C - atóm

Rafeindir með einingarhleðslu -e og róteindir með einingarhleðslu +e

Hleðsla varðveitist staðbundið og víðvært (um þær gildir samfelldnijafna)

Einingarhleðslur - lokuð eða opin kerfi - skömmtun hleðslu

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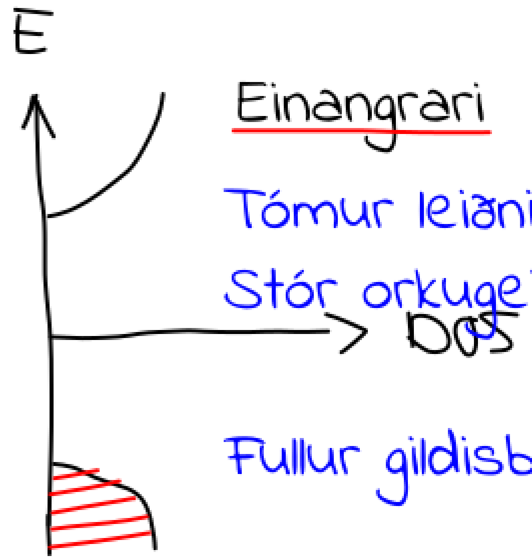
Orkustig - borðar í föstu efni, ástandaþéttleiki (DOS)

Einangrari

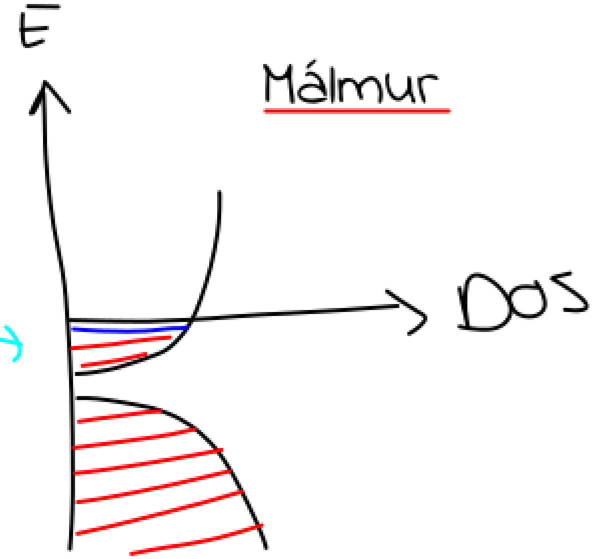


Tómur leiðniborði, engin leiðni

Stór orkugeil

Fullur gildisborði

Málmur



Rafeindir í leiðniborða auk tómra ástanda

--> mikil leiðni

Aðeins ein rafeind getur setið í hverju ástandi.

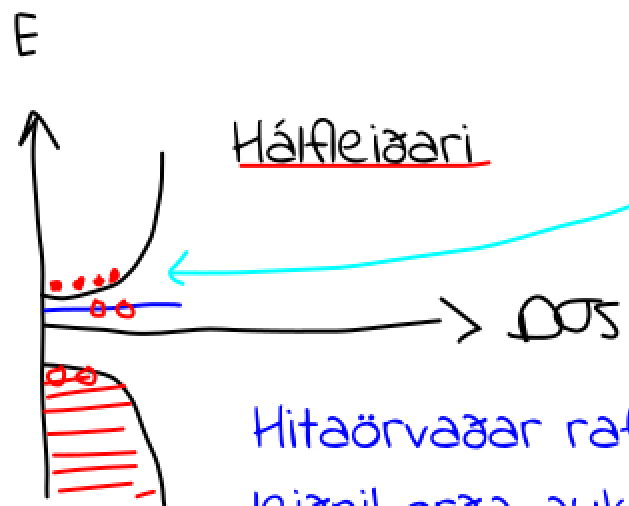
Til að hreyfa sig þurfa þær nálæg tóm ástönd

Í jafnvægi eru engir straumar

Kulgas

hlýgas

Hálfleiðari



Hitaörvaðar rafeindir upp í leiðniborða auk íbótar rafeinda

Stýranleg leiðni

Lögmál Coulombs

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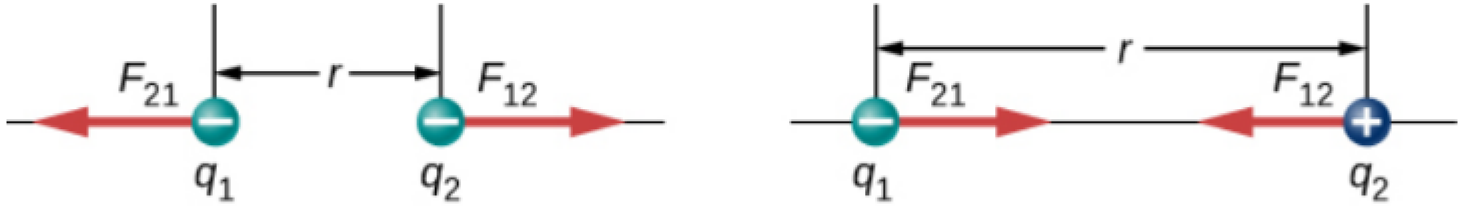
Coulomb's Law

The magnitude of the electric force (or **Coulomb force**) between two electrically charged particles is equal to

$$|\mathbf{F}_{12}| = \frac{1}{4\pi\varepsilon_0} \frac{|q_1 q_2|}{r_{12}^2} \quad (5.1)$$

The unit vector ***r*** has a magnitude of 1 and points along the axis as the charges. If the charges have the same sign, the force is in the same direction as ***r*** showing a repelling force. If the charges have different signs, the force is in the opposite direction of ***r*** showing an attracting force. (Figure 5.14).

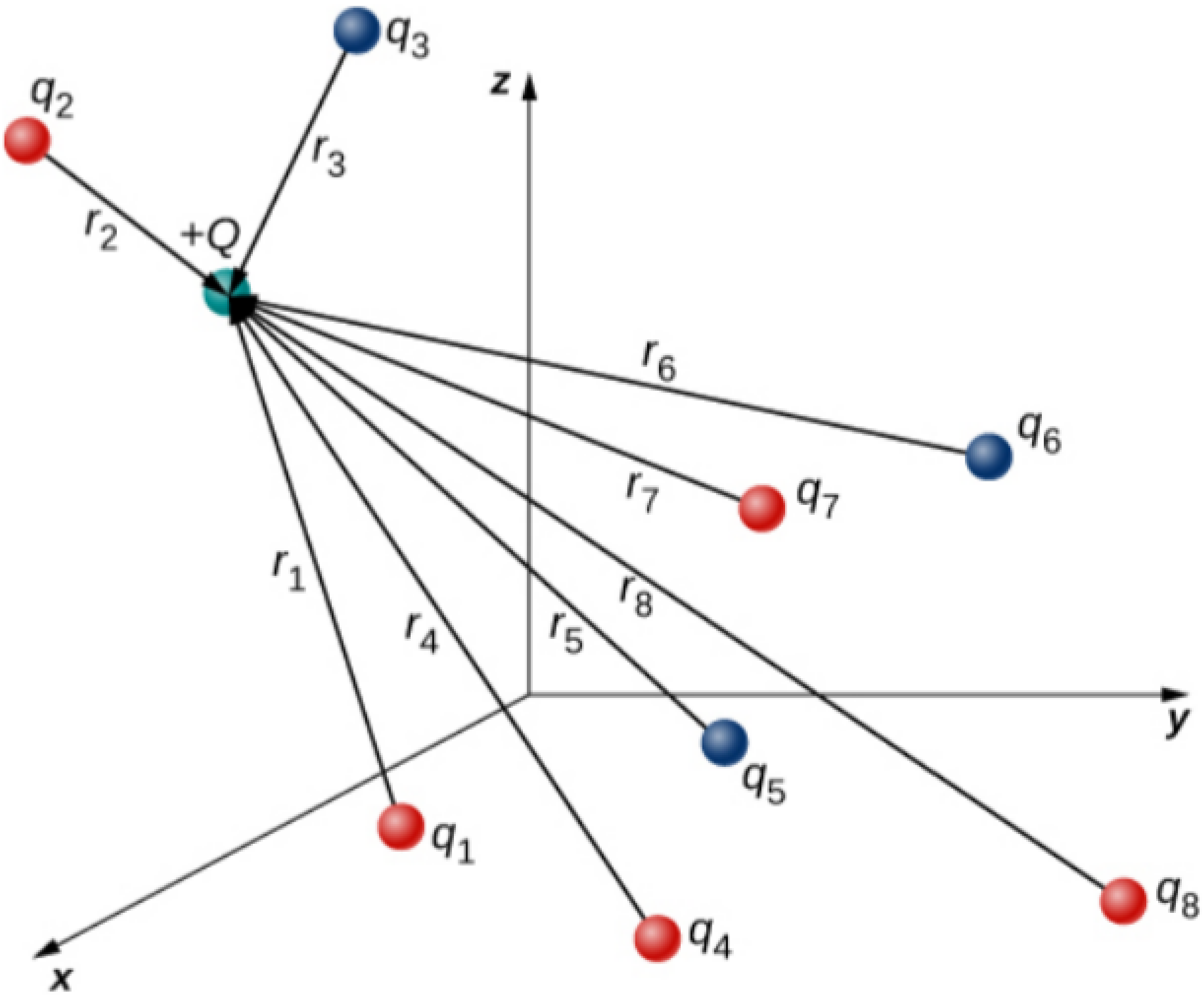


Samskonar lögmál gildir um aðdráttarkraft tveggja massa, en hleðslur geta haft sitt hvort formerkið, ekki massar

Í sígildu tómarúmi er rafsegulfræðin línuleg

$$\vec{\mathbf{F}}(r) = \frac{1}{4\pi\varepsilon_0} Q \sum_{i=1}^{N} \frac{q_i}{r_i^2} \hat{\mathbf{r}}_i$$

Principle of superposition



$\bar{F}(r)$ er krafturinn á hleðslu Q í punktinum $\bar{r}$, en $\bar{r}_i$ er vigur frá hleðslu q_i að Q

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Rafsvið - electrical field

$$\begin{aligned}\vec{\mathbf{F}} &= \vec{\mathbf{F}}_1 + \vec{\mathbf{F}}_2 + \vec{\mathbf{F}}_3 + \cdots + \vec{\mathbf{F}}_N \\ &= \frac{1}{4\pi\varepsilon_0}\left(\frac{Qq_1}{r_1^2}\hat{\mathbf{r}}_1 + \frac{Qq_2}{r_2^2}\hat{\mathbf{r}}_2 + \frac{Qq_3}{r_3^2}\hat{\mathbf{r}}_3 + \cdots + \frac{Qq_N}{r_1^2}\hat{\mathbf{r}}_N\right) \\ &= Q\left[\frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_1^2}\hat{\mathbf{r}}_1 + \frac{q_2}{r_2^2}\hat{\mathbf{r}}_2 + \frac{q_3}{r_3^2}\hat{\mathbf{r}}_3 + \cdots + \frac{q_N}{r_1^2}\hat{\mathbf{r}}_N\right)\right].\end{aligned}$$

Kraftar N hleðslna á hleðslu Q

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$$\vec{\mathbf{F}} = Q\vec{\mathbf{E}}$$

Skilgreinum rafsvið

$$\vec{\mathbf{E}} \equiv \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_1^2}\hat{\mathbf{r}}_1 + \frac{q_2}{r_2^2}\hat{\mathbf{r}}_2 + \frac{q_3}{r_3^2}\hat{\mathbf{r}}_3 + \cdots + \frac{q_N}{r_1^2}\hat{\mathbf{r}}_N\right)$$

Vigursvið í öllum punktum rúmsins

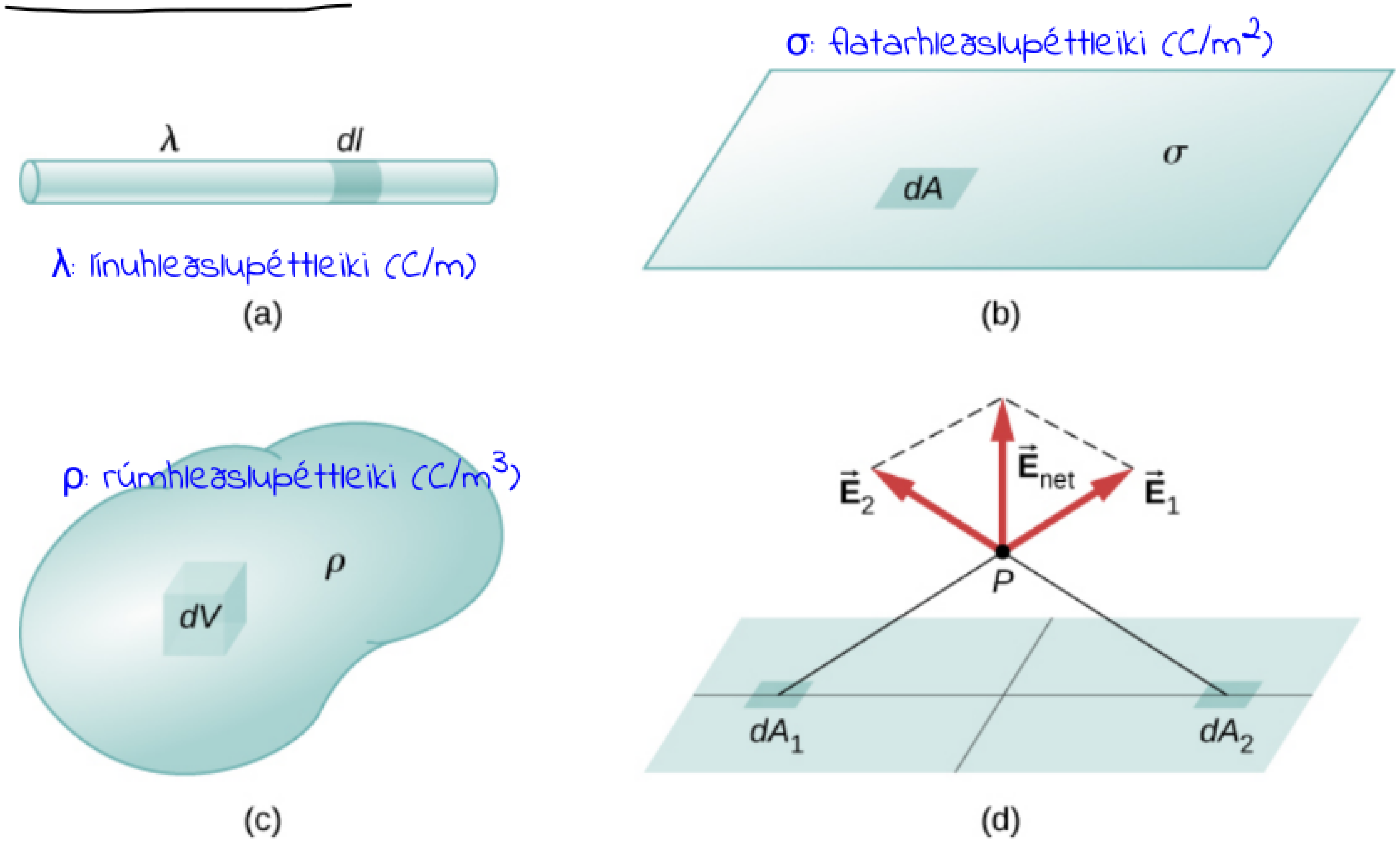
$$\vec{\mathbf{E}}(P) \equiv \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{N}\frac{q_i}{r_i^2}\hat{\mathbf{r}}_i.$$

Línuleg samantekt eins og fyrir kraftsviðið

Direction of the Electric Field

By convention, all electric fields $\vec{\mathbf{E}}$ point away from positive source charges and point toward negative source charges.

Samfelld hleðsla



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Point charges: $$\vec{\mathbf{E}}(P) = \frac{1}{4\pi\varepsilon_0} \sum_{i=1}^{N} \left(\frac{q_i}{r^2} \right) \hat{\mathbf{r}}$$

Line charge: $$\vec{\mathbf{E}}(P) = \frac{1}{4\pi\varepsilon_0} \int_{\text{line}} \left(\frac{\lambda dl}{r^2} \right) \hat{\mathbf{r}}$$

Einingarvigur frá hleðslufrymi til athuganda

Surface charge: $$\vec{\mathbf{E}}(P) = \frac{1}{4\pi\varepsilon_0} \int_{\text{surface}} \left(\frac{\sigma dA}{r^2} \right) \hat{\mathbf{r}}$$

Volume charge: $$\vec{\mathbf{E}}(P) = \frac{1}{4\pi\varepsilon_0} \int_{\text{volume}} \left(\frac{\rho dV}{r^2} \right) \hat{\mathbf{r}}$$

P: Staðsetning athuganda
r: Fjarlægð hleðslufrymis frá athuganda

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Ex. 5.8

Rafsvið beint ofan jafnhlaðinnar skífu

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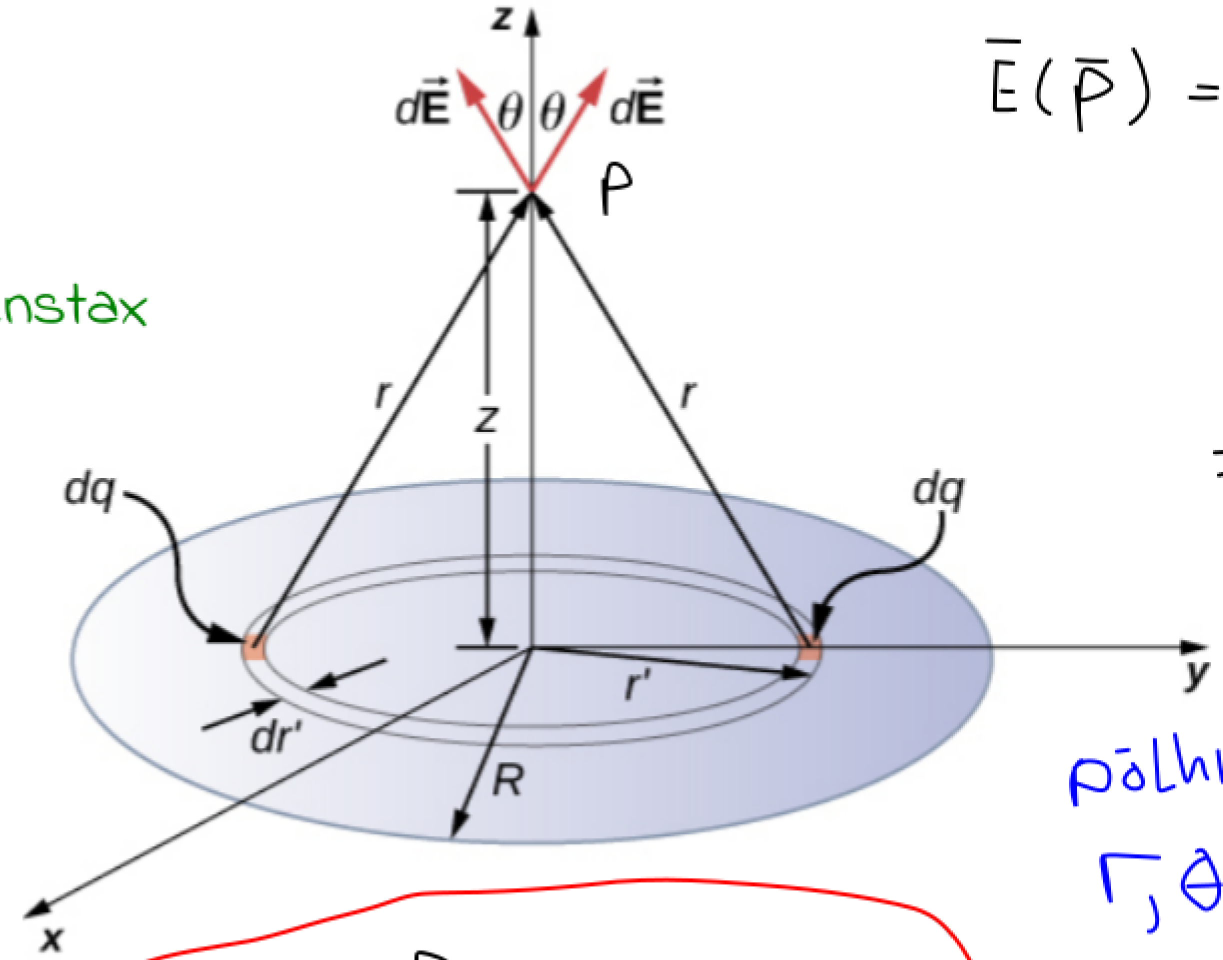

$$\bar{E}(\bar{P}) = \frac{1}{4\pi\epsilon_0}\int_S \frac{\sigma\, dA}{r^2}\,\hat{r}$$

$$= \frac{1}{4\pi\epsilon_0}\int_S \frac{\sigma\, dA}{r^2}\cos\theta \cdot \hat{k}$$

pólhnit → sívalningshnit

r, θ, z

$$dA = 2\pi r' dr'$$

$$r^2 = r'^2 + z^2$$

$$\cos\theta = \frac{z}{\sqrt{r'^2 + z^2}}$$

$$\bar{E}(P) = \bar{E}(z) = \frac{1}{4\pi\epsilon_0}\int_0^R \frac{\sigma(2\pi r' dr')\, z}{(r'^2 + z^2)^{3/2}}\,\hat{k}$$

$$= \frac{1}{4\pi\epsilon_0}(2\pi\sigma z)\left[\frac{1}{z} - \frac{1}{\sqrt{R^2+z^2}}\right]\hat{k}$$

$$= \frac{1}{4\pi\epsilon_0}\left[2\pi\sigma - \frac{2\pi\sigma z}{\sqrt{R^2+z^2}}\right]\hat{k}$$ ← Nákvæm lausn

Aðfellulausn fyrir $z >> R$

$$\xrightarrow[z >> R]{} \simeq \frac{1}{4\pi\epsilon_0}\frac{\sigma\pi R^2}{z^2}\hat{k} = \frac{1}{4\pi\epsilon_0}\frac{Q_T}{z^2}\hat{k}$$

Úr mikilli hæð "lítur" diskurinn út eins og punkthleðsla $Q_T = \sigma\pi R^2 = \sigma A$

Rafsvið - sviðslínur

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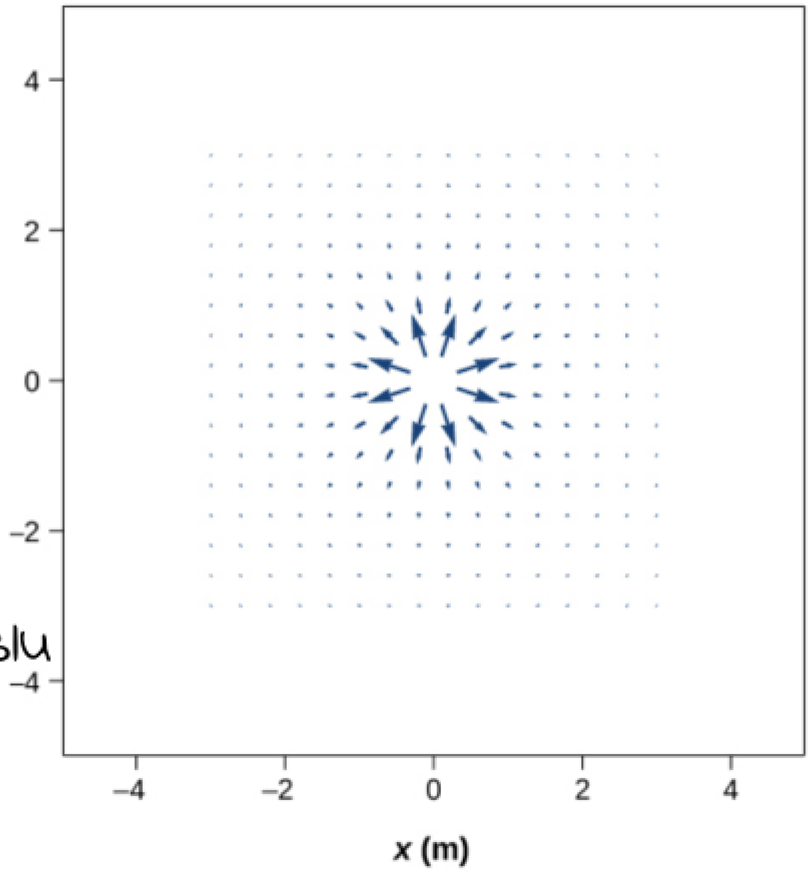
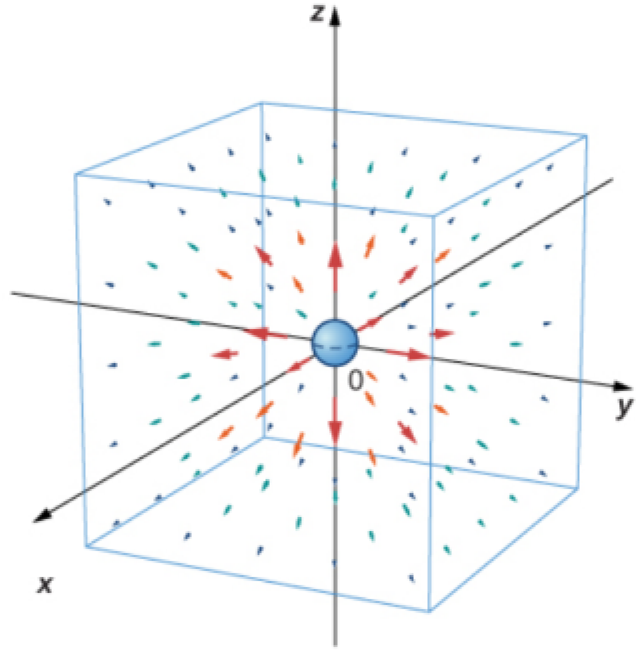
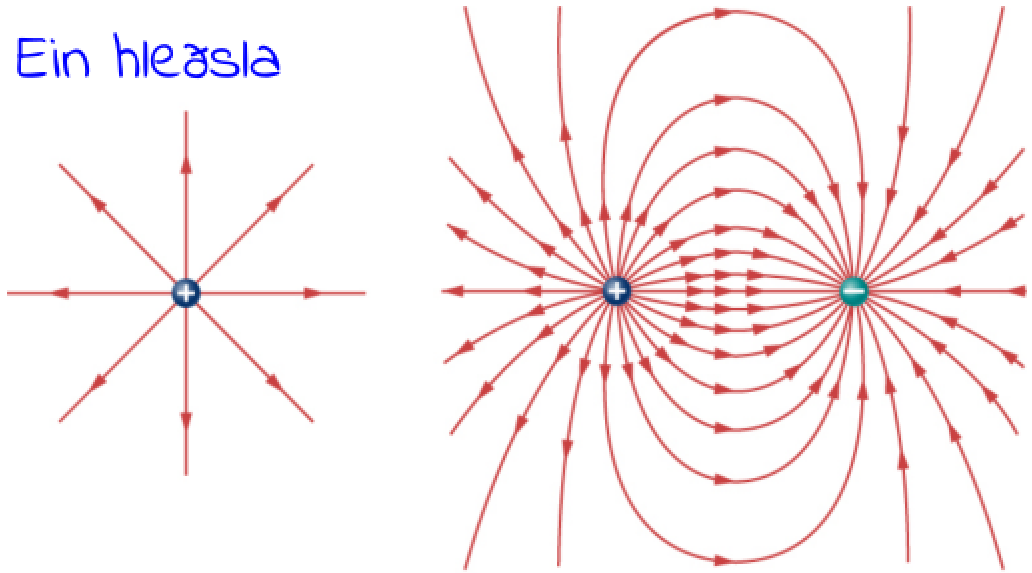
Línufjöldi í réttu hlutfalli við hleðslu
Hefjast alltaf í +hleðslu og enda alltaf í -hleðslu





Ein hleðsla

Ein hleðsla



(a)

(b)

Tvær jafnstórar hleðslur
-- tvískaut

Sviðslínur skerast aldrei
(þá væri sviðið ekki einkvæmt)
Flæði ...

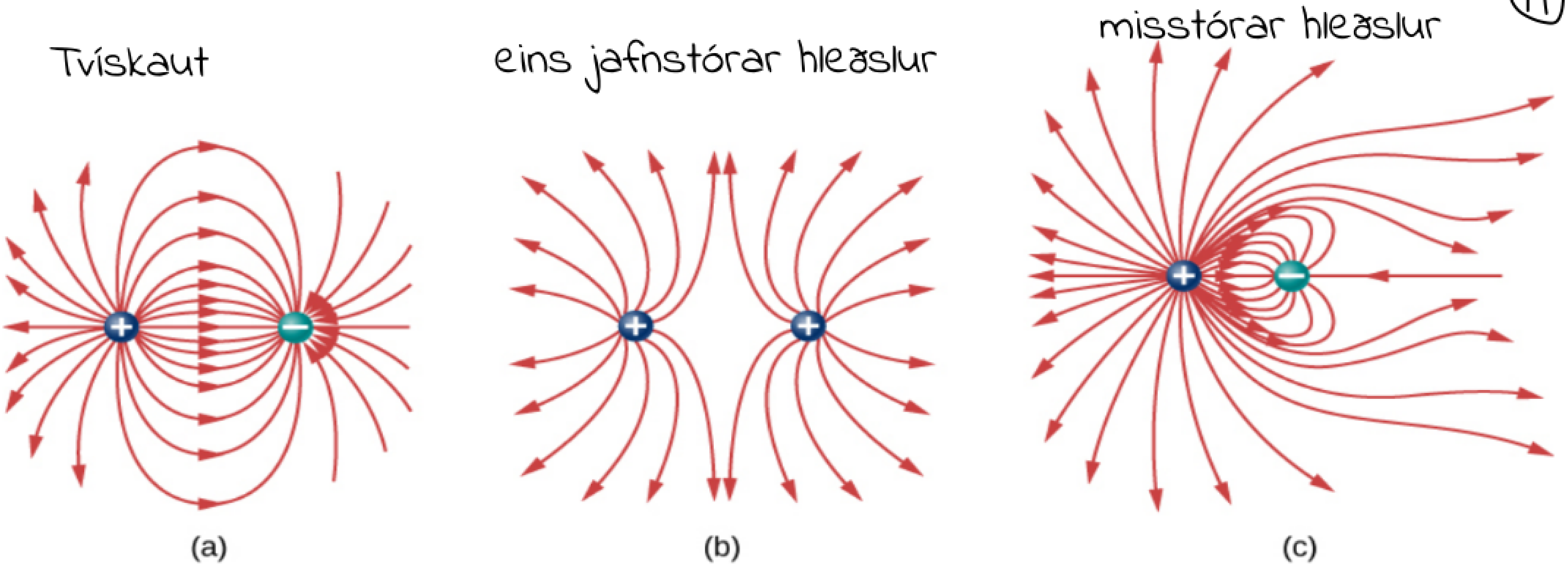


Figure 5.31 Three typical electric field diagrams. (a) A dipole. (b) Two identical charges. (c) Two charges with opposite signs and different magnitudes. Can you tell from the diagram which charge has the larger magnitude?

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vægi á tvískaut

$$\begin{aligned}\vec{\tau} &= \left(\frac{\vec{\mathbf{d}}}{2} \times \vec{\mathbf{F}}_+\right) + \left(-\frac{\vec{\mathbf{d}}}{2} \times \vec{\mathbf{F}}_-\right) \\ &= \left[\left(\frac{\vec{\mathbf{d}}}{2}\right) \times \left(+q\vec{\mathbf{E}}\right) + \left(-\frac{\vec{\mathbf{d}}}{2}\right) \times \left(-q\vec{\mathbf{E}}\right)\right] \\ &= q\vec{\mathbf{d}} \times \vec{\mathbf{E}}.\end{aligned}$$

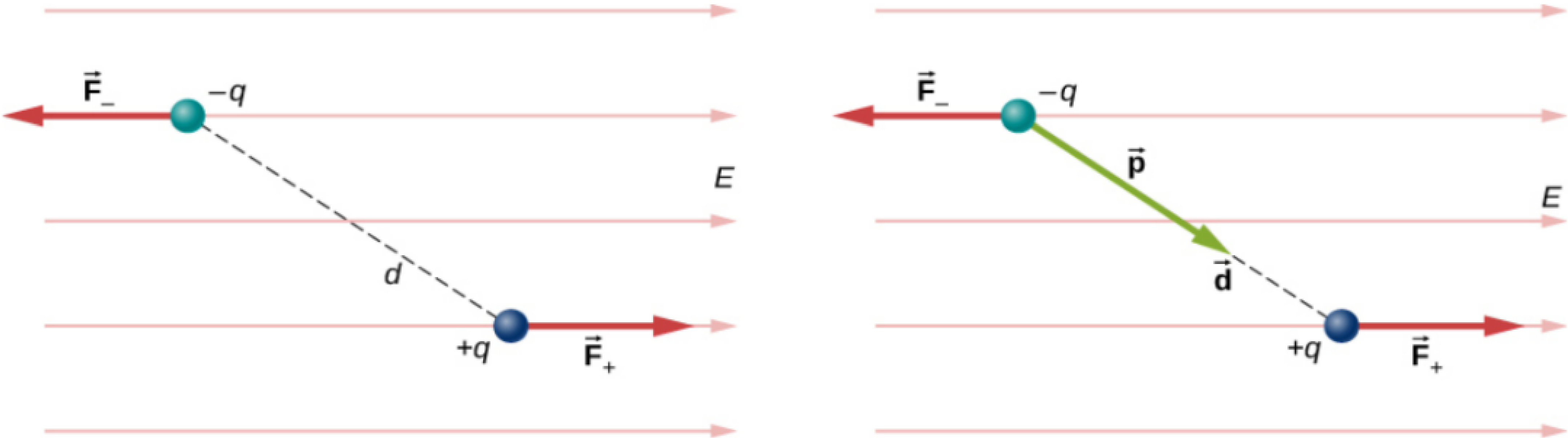

Figure 5.32 A dipole in an external electric field. (a) The net force on the dipole is zero, but the net torque is not. As a result, the dipole rotates, becoming aligned with the external field. (b) The dipole moment is a convenient way to characterize this effect. The $\vec{\mathbf{d}}$ points in the same direction as $\vec{\mathbf{p}}$.

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Tvískaut, stefna og vægi

$$\vec{\mathbf{p}} \equiv q\vec{\mathbf{d}}.$$

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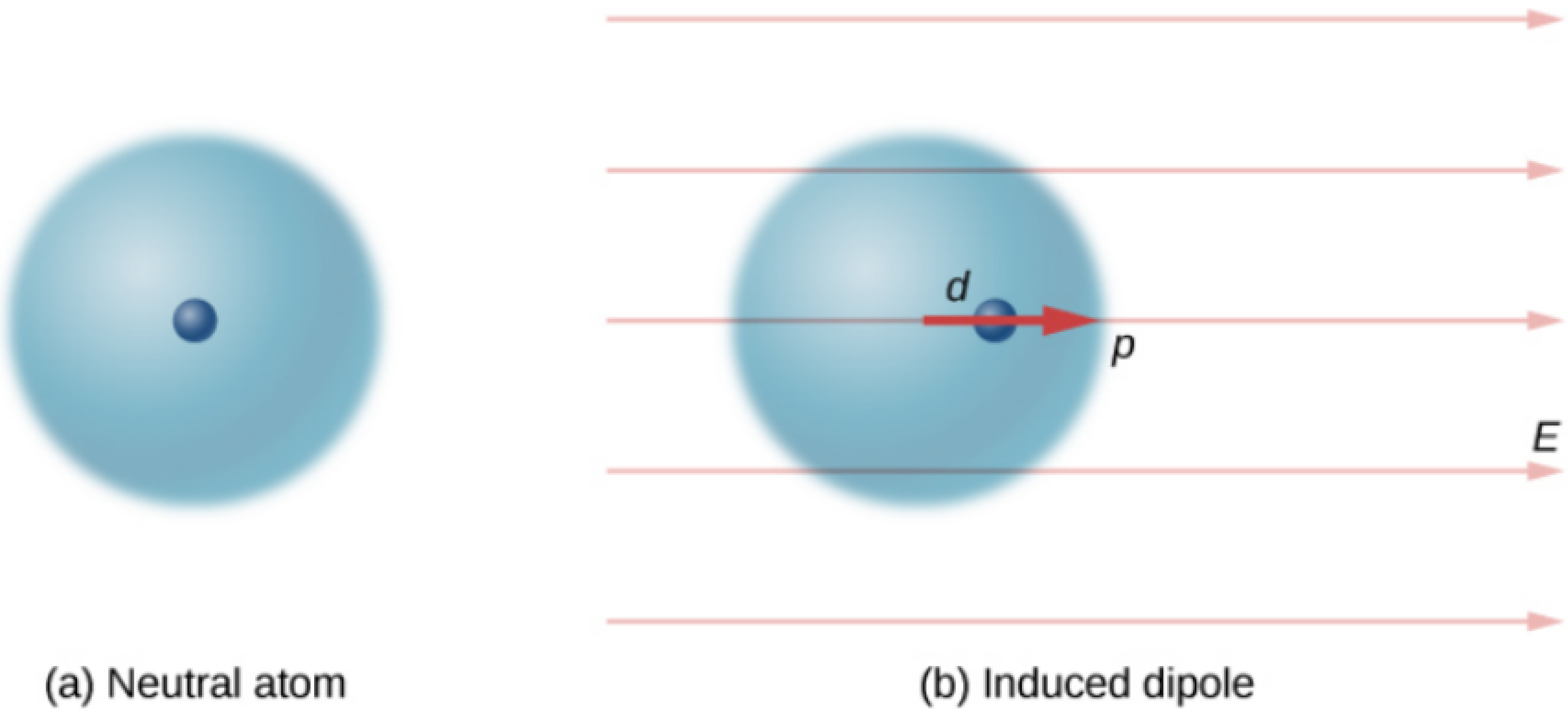
$$\vec{\tau} = \vec{\mathbf{p}} \times \vec{\mathbf{E}}.$$

Skautað tvískaut



A dipole is induced in a neutral atom by an external electric field. The induced dipole moment is aligned with the external

Skautun milli atóma vegna flökkts --> veikir aðdráttarkraftar, víxlverkun van der waals

$$V(r) \sim \frac{1}{r^6}$$

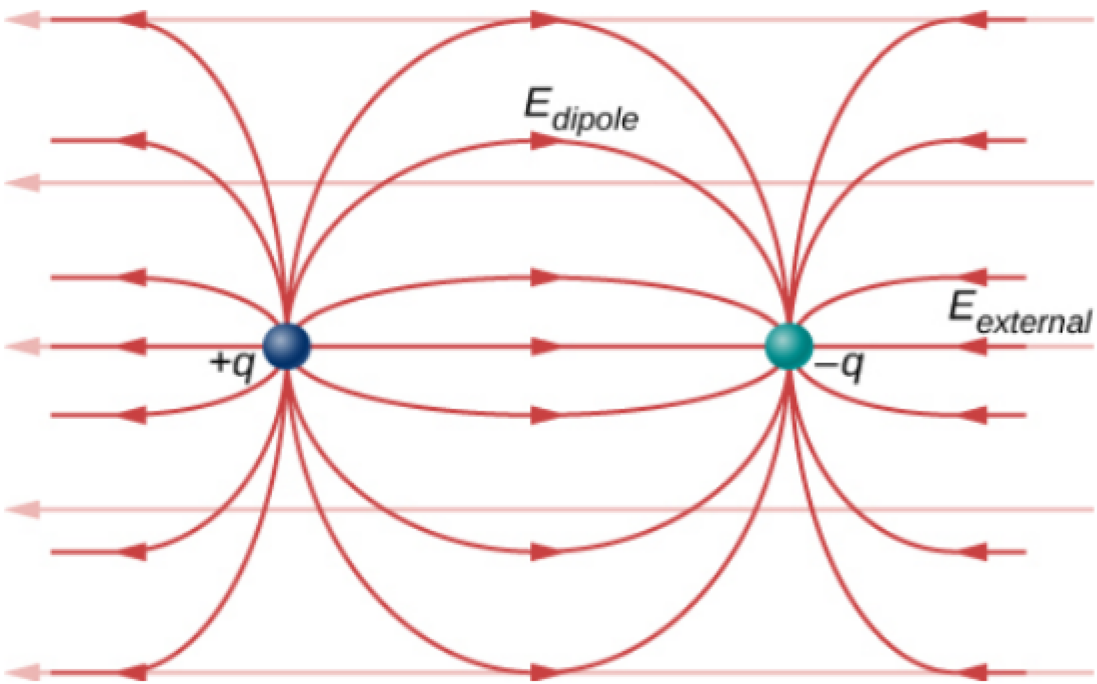


Figure 5.34 The net electric field is the vector sum of the field of the dipole plus the external field.

Recall that we found the electric field of a dipole in Equation 5.7. If we rewrite it in terms of the dipole moment we get:

Svið tvískauts

$$\vec{\mathbf{E}}(z) = \frac{-1}{4\pi\varepsilon_0}\frac{\vec{\mathbf{p}}}{z^3}.$$

skammseilið svið