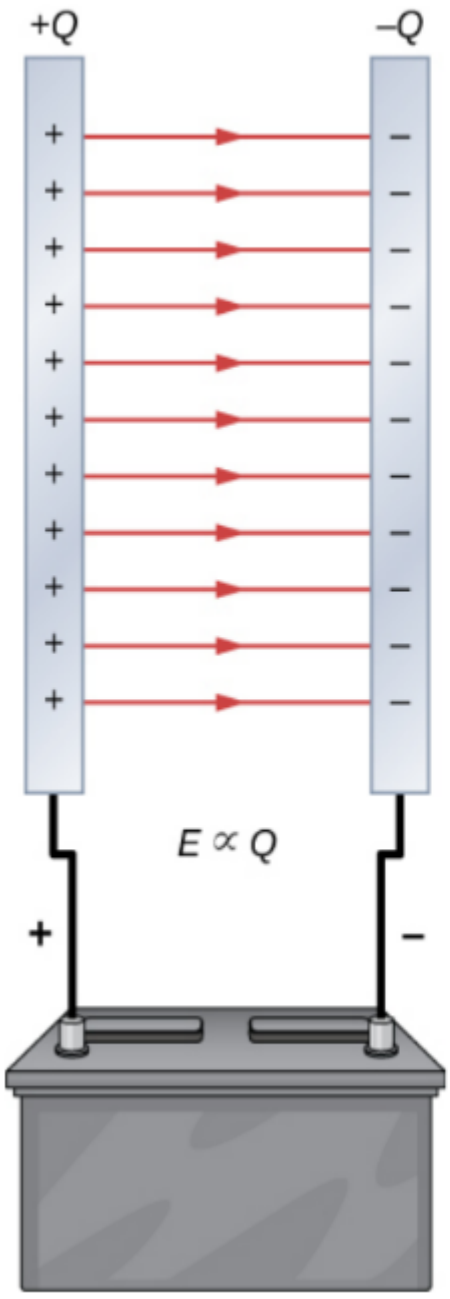
Rýmd - capacitance



Rafkraftar milli hleðslna á leiðurum halda hleðslunum þar, rýmd er skilgreind sem

$$C = \frac{Q}{V}$$

Eining

$$1\,\mathrm{F} = \frac{1\,\mathrm{C}}{1\,\mathrm{V}}$$

Almennur eiginleiki leiðara, ský getur líka haft rýmd miðað við jörð...

Þéttar eru mikilvægir í rafrásum, þeir geta einnig geymt rafhleðslu og verkað sem "rafgeymar"

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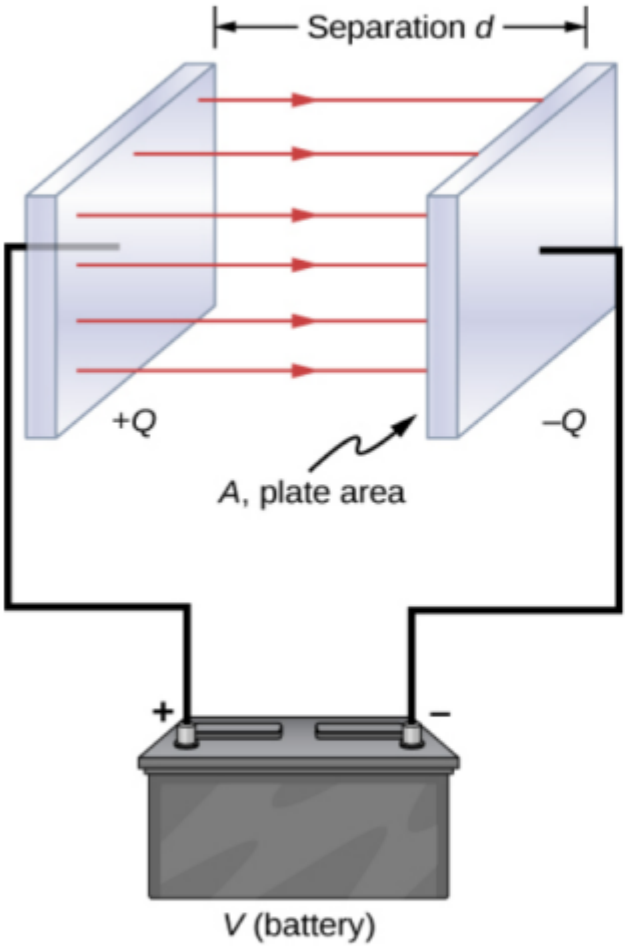
Rýmd plötupéttis



Hleðslupéttleiki á plötu

$$\sigma = \frac{Q}{A}$$

$$\rightarrow \quad E = \frac{\sigma}{\epsilon_0}$$ fastur sviðsstyrkur

$$\rightarrow \quad V = Ed = \frac{\sigma d}{\epsilon_0} = \frac{Qd}{\epsilon_0 A}$$

$$\rightarrow \quad \boxed{C = \frac{Q}{V} = \frac{Q\epsilon_0 A}{Qd} = \epsilon_0 \frac{A}{d}}$$

Rýmd einfalds línulegs péttis er aðeins háð lögun hans (og efninu milli platnanna)

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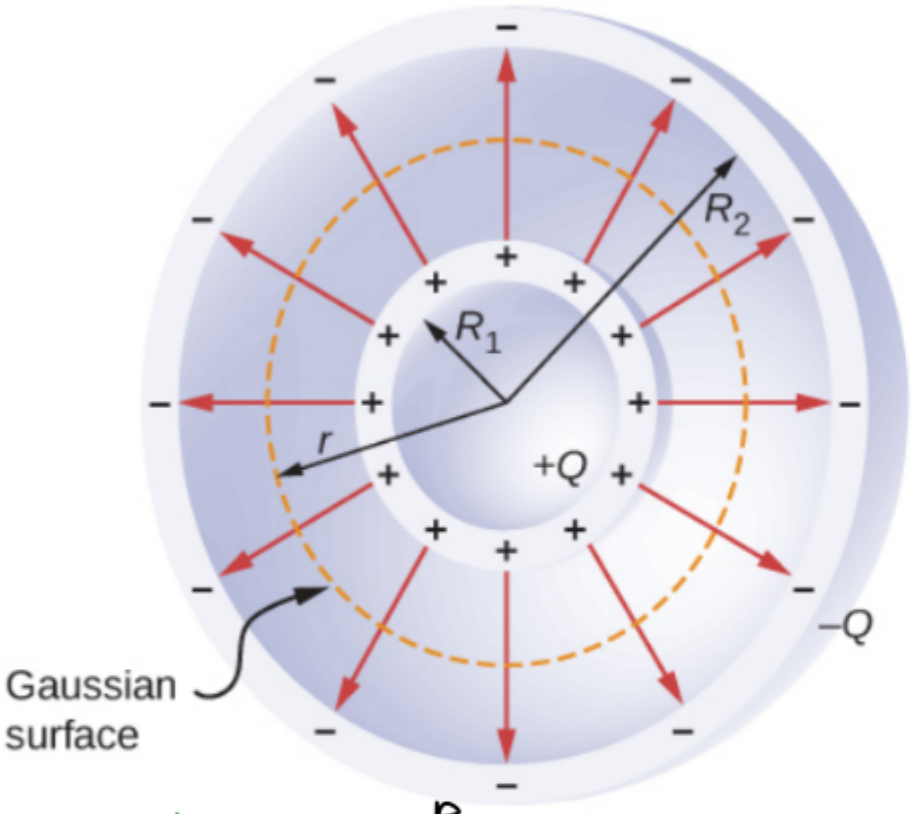
Rýmd kúlupéttis



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$$\rightarrow V = \frac{Q}{4\pi\epsilon_0}\int_{R_1}^{R_2}\frac{dr}{r^2} = \frac{Q}{4\pi\epsilon_0}\left\{\frac{1}{R_1}-\frac{1}{R_2}\right\}$$

$$\rightarrow C = \frac{Q}{V} = 4\pi\epsilon_0\frac{R_1R_2}{R_2-R_1}$$

Milli kúluskeljanna

$$\oint_S \bar{E}\cdot d\bar{A} = \frac{Q}{\epsilon_0}$$ Lögmál Gauß

$$E(4\pi r^2) = \frac{Q}{\epsilon_0}$$

$$\rightarrow \bar{E} = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}\hat{r}$$

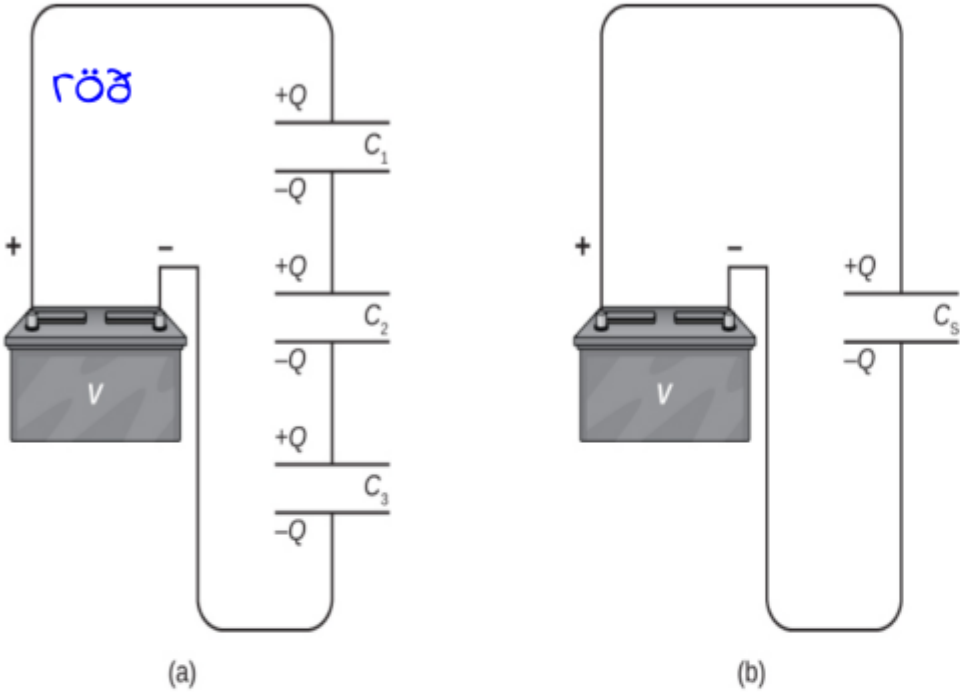
$$V = \int_{R_1}^{R_2}\bar{E}\cdot d\bar{l} = \int_{R_1}^{R_2}\frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}\hat{r}\cdot(\hat{r}\cdot dr)$$

Rýmd einnar kúlu, $R_2 \rightarrow \infty$

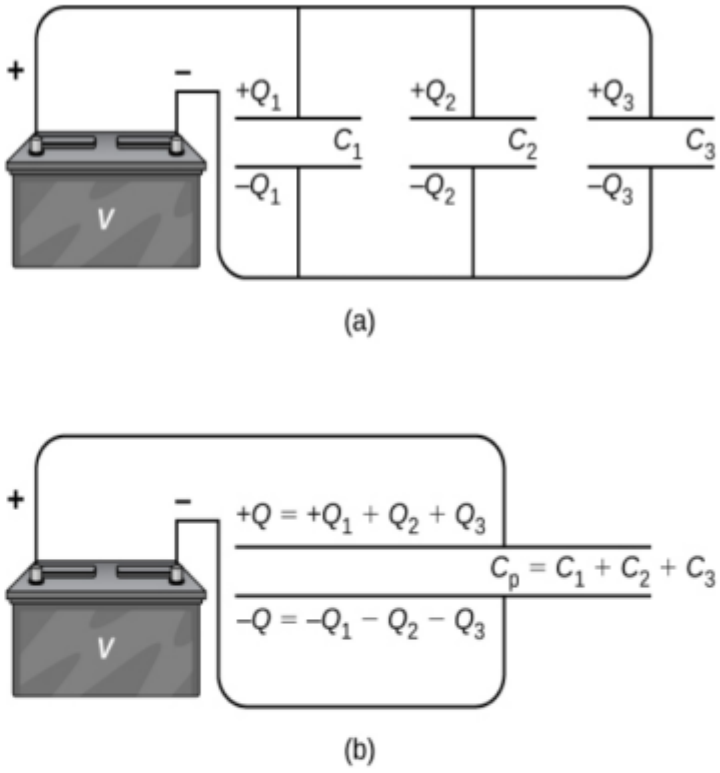
$$C = 4\pi\epsilon_0 R_1$$

Uppröðun þétta

röð



Samsíða



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$$V = V_1 + V_2 + V_3$$

$$\frac{Q}{C_s} = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$$

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$Q_p = Q_1 + Q_2 + Q_3$$

$$C_p V = C_1 V + C_2 V + C_3 V$$

→ $$C_p = C_1 + C_2 + C_3$$

orka í þétti

Flutningur á hleðslu dq frá annarri þéttaplötunni yfir á hina krefst vinnu

$$dW = V\,dq = \frac{q}{C}\,dq$$

$$\rightarrow \boxed{W = \int_0^{W(Q)} dW = \int_0^Q \frac{q}{C}\,dq = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2 = \frac{1}{2}QV} = U_C$$

tengist V, Q og C sem tengja má við þéttinn og plötur hans, en hver er orkuþéttleikinn í geilinni milli platnanna

$$u_E = \frac{U_C}{Ad} = \frac{1}{2}\frac{Q^2}{C}\frac{1}{Ad} = \frac{1}{2}\frac{Q^2}{\varepsilon_0 A/d}\frac{1}{Ad} = \frac{1}{2}\frac{1}{\varepsilon_0}\left(\frac{Q}{A}\right)^2 = \frac{\sigma^2}{2\varepsilon_0} = \frac{(E\varepsilon_0)^2}{2\varepsilon_0} = \frac{\varepsilon_0}{2}E^2$$

rafsviðið eða rafmættið í geilinni milli platnanna hefur orkuþéttleika

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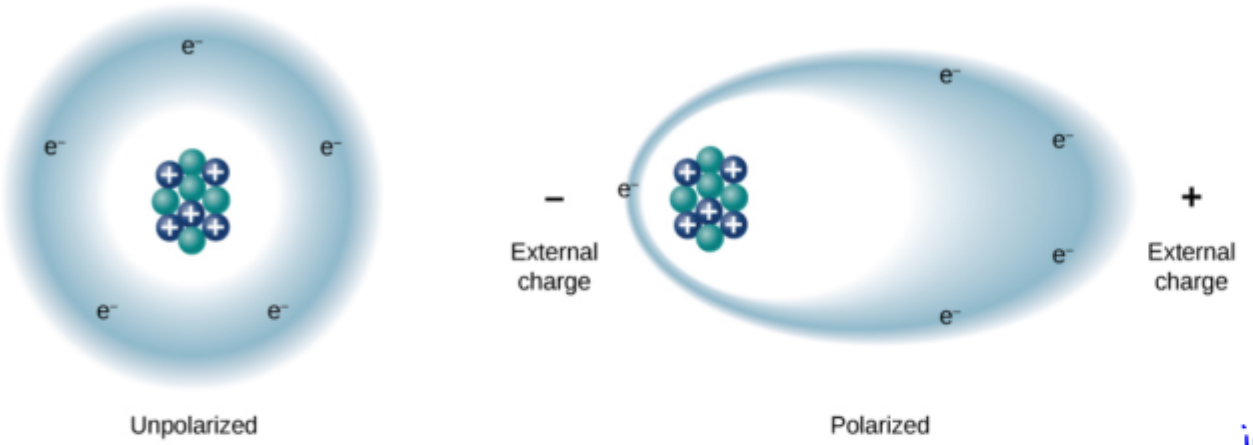
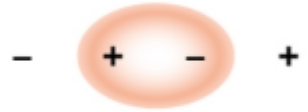
Rafsvarar - dielectric

Áhrif ytra rafsviðs á atóm -- skautun





induced electric dipole moment skautað tvískautsvægi

Áhrif ytra rafsviðs á einangrandi efni sem getur skautast

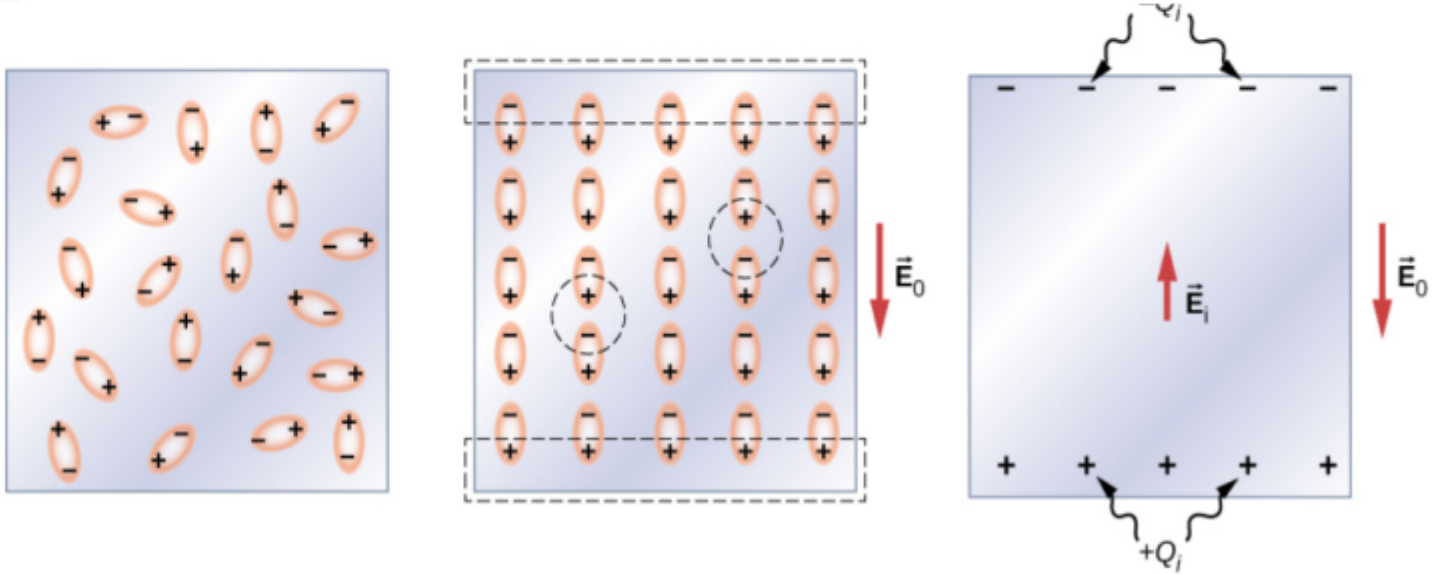


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Figure 8.20 A dielectric with polar molecules: (a) In the absence of an external electrical field; (b) in the presence of an external electrical

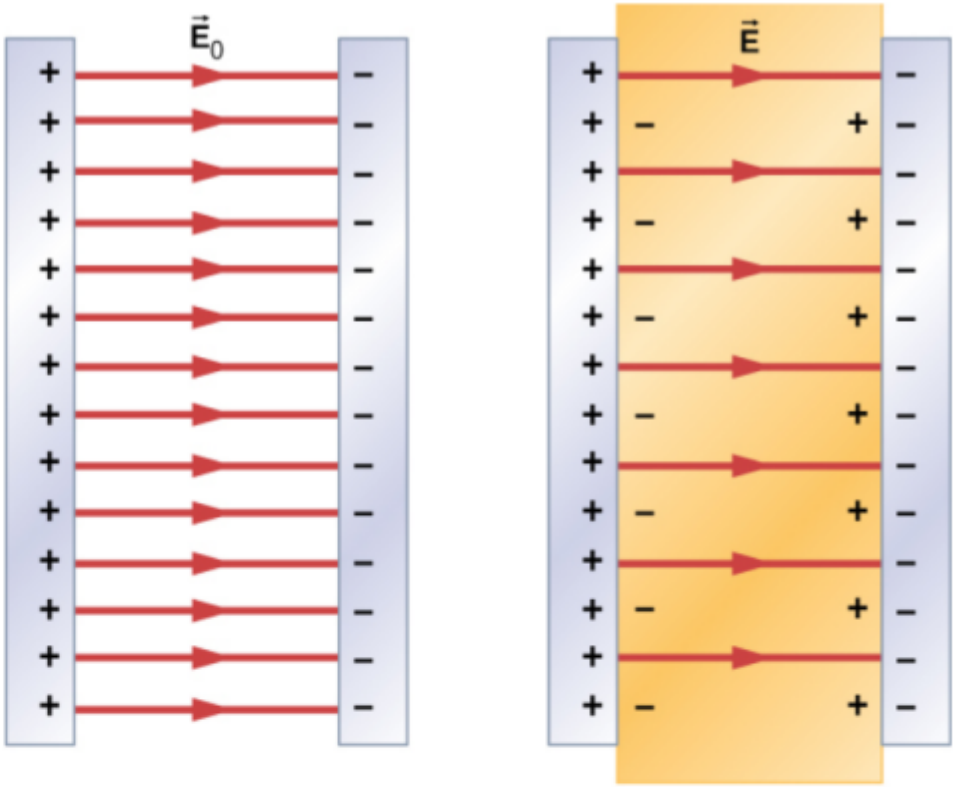
Áhrif rafsvara á rýmd

Hleðslan Q_0 veldur E_0 inni í þéttinum
Skautun rafsvarans leggur til E_i
Heildarrafsviðið er

$$\vec{E} = \vec{E}_0 + \vec{E}_i$$

Fyrir línulega rafsvara

$$E_0 = kE$$



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skilgreining rafsvörunarfastans **κ** (gríska kappa), **κ > 1**

$$C = kC_0 \,, \qquad U = \frac{1}{K} U_0$$

Rýmdin vex með rafsvara,
orkan geymd minnkar

Rafsegulfræði í efni er miklu flóknari en rafsegulfræðin fyrir stakar hleðslur í tómarúmi

Straumar - leiðni - viðnám

Færumst frá jafnvægi yfir í sístætt ástand (steady state)

Electrical Current

The average electrical current I is the rate at which charge flows,

$$I_{\text{ave}} = \frac{\Delta Q}{\Delta t}, \tag{9.1}$$

where ΔQ is the amount of net charge passing through a given cross-sectional area in time Δt (Figure 9.2). The SI unit for current is the **ampere** (A), named for the French physicist André-Marie Ampère (1775–1836). Since $I = \frac{\Delta Q}{\Delta t}$, we see that an ampere is defined as one coulomb of charge passing through a given area per second:

$$1\text{A} \equiv 1\frac{\text{C}}{\text{s}}. \tag{9.2}$$

The instantaneous electrical current, or simply the **electrical current**, is the time derivative of the charge that flows and is found by taking the limit of the average electrical current as $\Delta t \to 0$:

$$I = \lim_{\Delta t \to 0} \frac{\Delta Q}{\Delta t} = \frac{dQ}{dt}. \tag{9.3}$$

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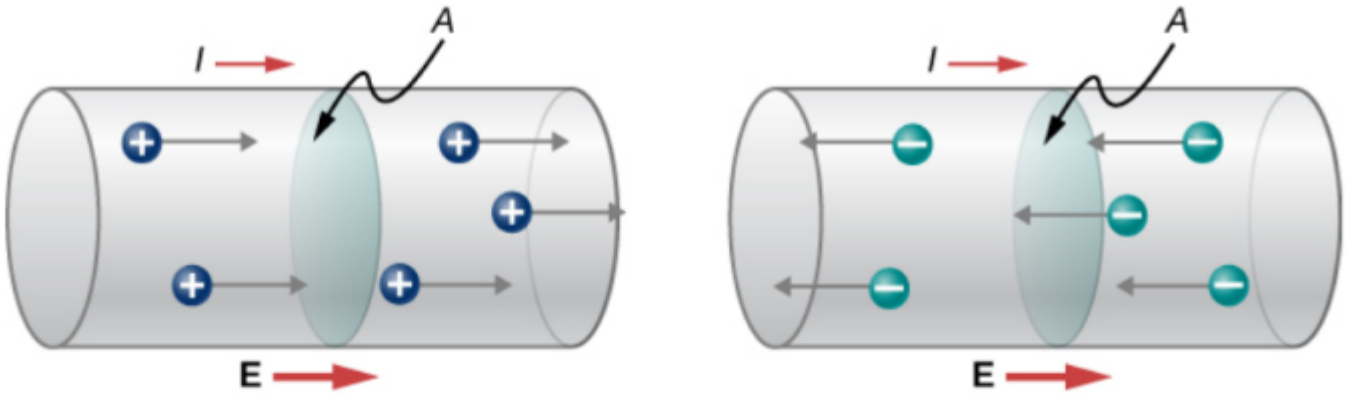
Hvað flæðir?



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+ hlaðnar eindir

samkvæmt skilgreiningu sem er eldri en þekking á rafeindum

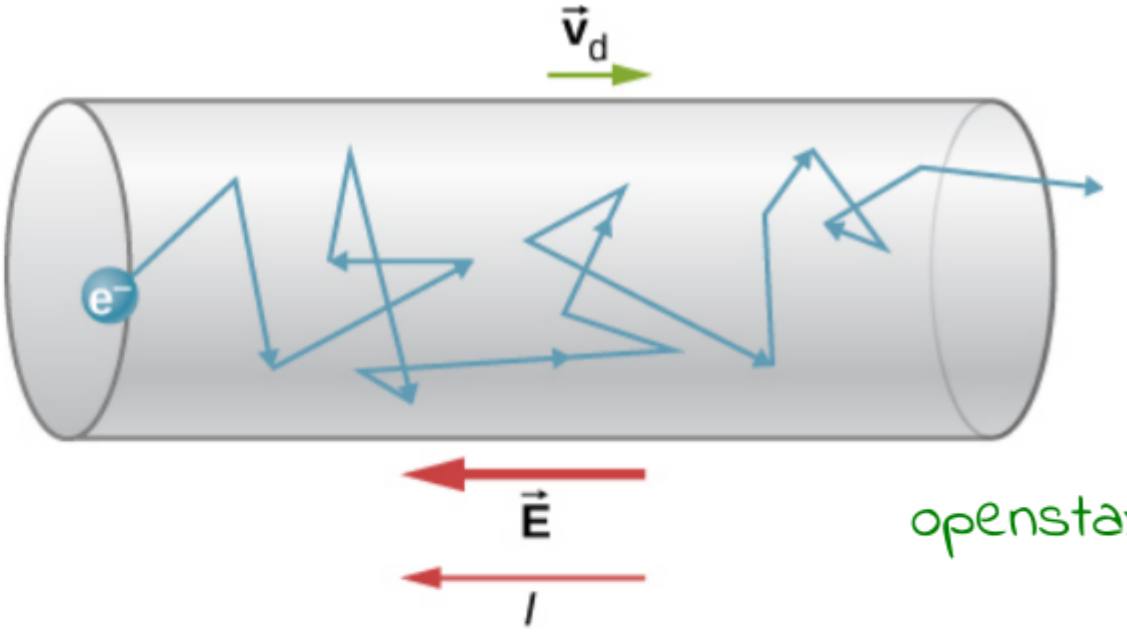
rafeindir?

Málið er flóknara. Vissulega flæða rafeindir, en það er einfaldara að skoða flæði "sýndareinda" (quasi-particles) sem geta verið með + eða - hleðslu, eða jafnvel hleðslu sem er brot af e, einingarhleðslunni

Sýndareindirnar koma fram í tilraunum og reikningum, sem veikt víxlverkandi einingar....

Rekhraði - drift velocity

Rafeindagas í leiðara
mikill hraði - tíðir árekstrar
(rafeindir - hljóðeindir - óreglur
í kristalli) --> lítill rekhraði



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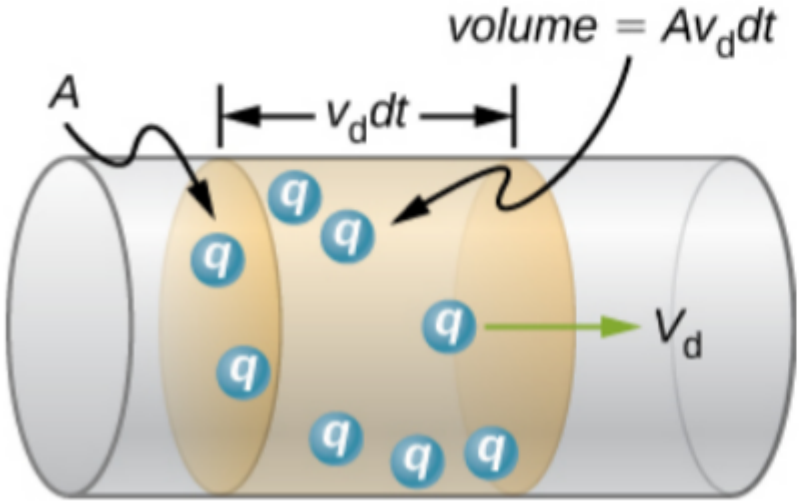
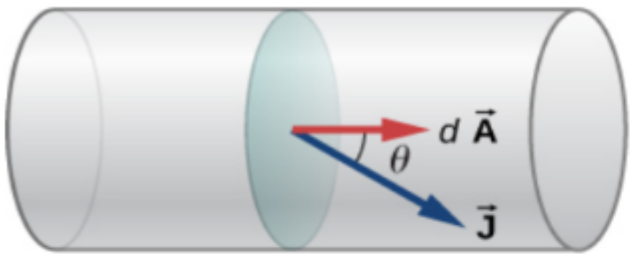


$$I = \frac{dQ}{dt} = q n A v_d$$

n: eindaþéttleiki

$$v_d = \frac{I}{nqA}$$

Straumþéttleiki $\vec{J}$



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$$I = \int_A \vec{J} \cdot d\vec{A}$$

$$J = \frac{I}{A} = \frac{n|q|Av_d}{A} = n|q|v_d$$

$$\rightarrow \quad \vec{J} = nq\vec{v}_d$$

Eðlisleiðni - conductivity

Fyrir línulega svörun við ytra rafsviði gildir

$$\vec{J} = \sigma \vec{E}$$

eining σ er $A/(Vm)$

Í smásæjum líkönum er eðlisleiðni eða leiðni reiknuð, en oft er eðlisviðnám eða viðnám mælt

$$\vec{E} = \rho \vec{J}$$

$$\rho = \frac{1}{\sigma}$$

eining ρ er $\Omega m = \frac{V}{A} m$

Viðnám - leiðni (resistance - conductance)

Resistance

The ratio of the voltage to the current is defined as the **resistance** R:

Lögmál Ohms

$$R \equiv \frac{V}{I}. \qquad V = RI \qquad 9.8$$

The resistance of a cylindrical segment of a conductor is equal to the resistivity of the material times the length divided by the area:

$$R \equiv \frac{V}{I} = \rho \frac{L}{A}. \qquad 9.9$$

$$I = GV$$

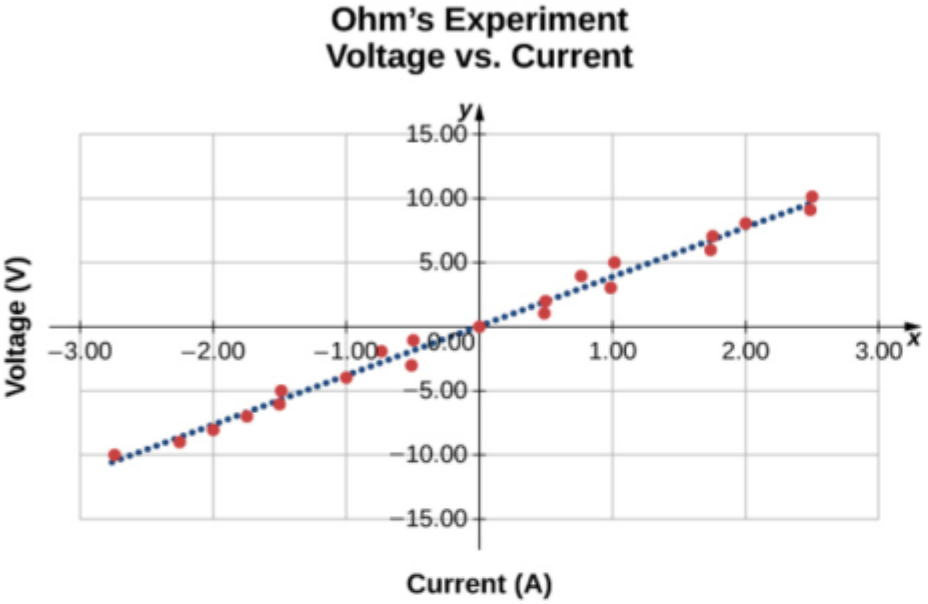
G: leiðni

Ef áhrif T eru línuleg fæst

$$R = R_0 \{1 + \alpha \Delta T\}$$

Landauer: Allar reikniaðgerðir í tölvu kosta orku

Línuleg eða ólínuleg leiðni

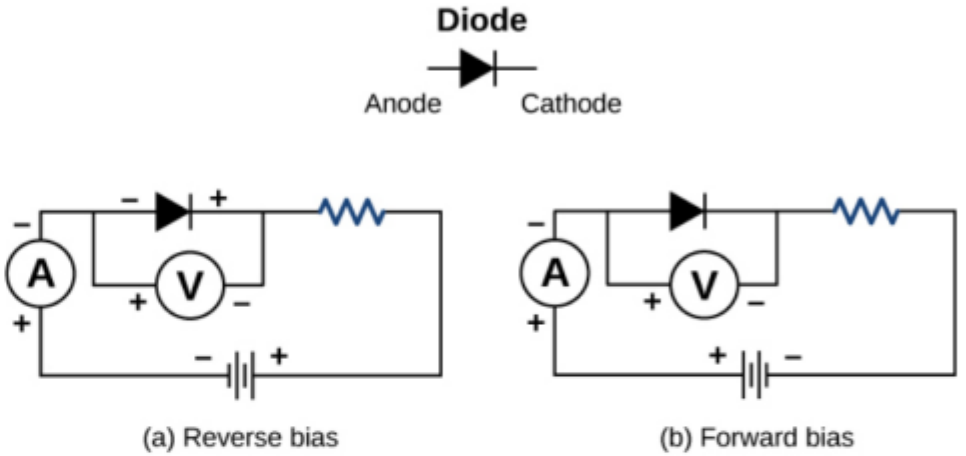


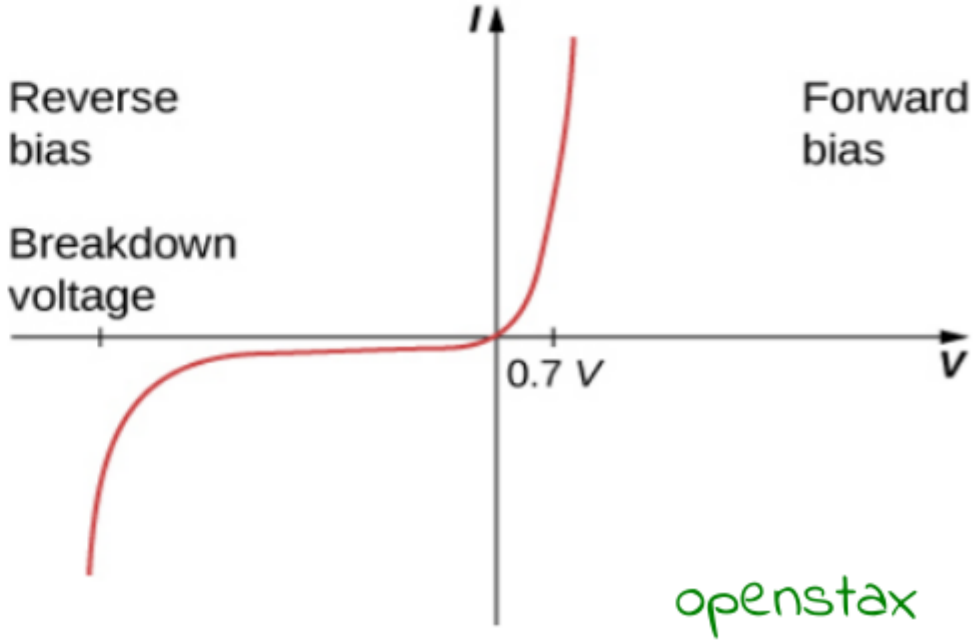
$V = IR$
$R = 3.84\Omega$

$$V = IR$$

Lögmál Ohms

Tvistur - diode





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Rafafl - raforka

opin kerfi með orkutapi

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Electric Power

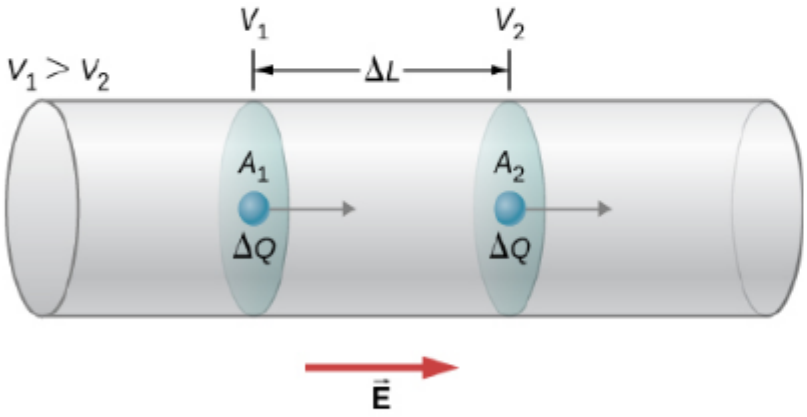
The electric power gained or lost by any device has the form

$$P = IV. \tag{9.12}$$

The power dissipated by a resistor has the form

$$P = I^2 R = \frac{V^2}{R}. \tag{9.13}$$

$\bar{F} = \Delta q t$



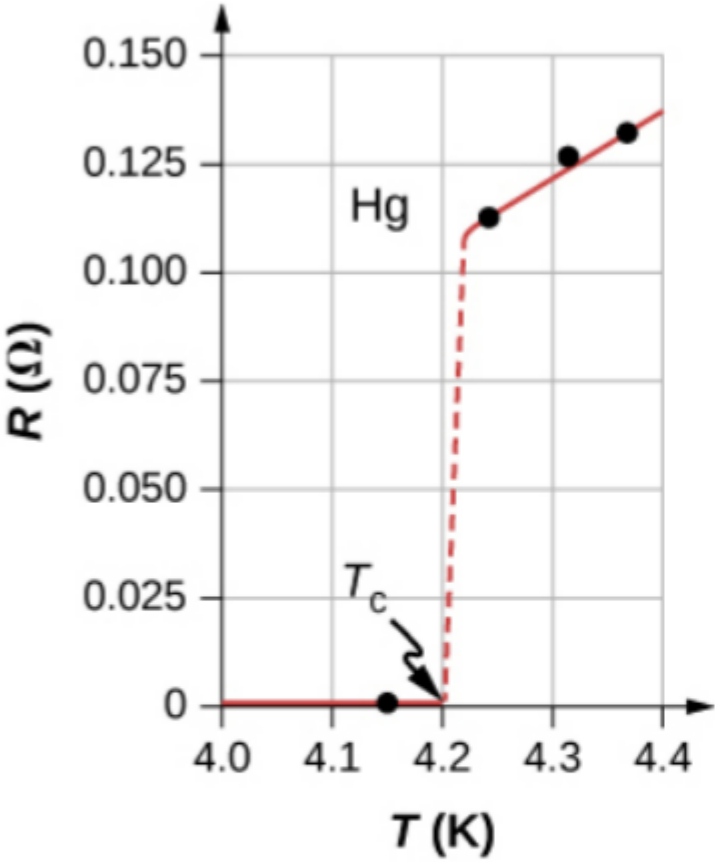
$$E = -\frac{(V_2 - V_1)}{\Delta L} = \frac{V}{\Delta L}$$

$$W = F\Delta L = (\Delta Q E)\Delta L = \left(\Delta Q \frac{V}{\Delta L}\right)\Delta L$$

$$= \Delta Q V = \Delta U$$

$$P = \frac{\Delta U}{\Delta t} = -\frac{\Delta Q V}{\Delta t} = I V$$

Ofurleiðni



Til eru efni sem missa allt viðnám undir vissu hitastigi

Suma má skilja með BCS-líkaninu sem segir að rafeindir parist í Cooper-pör í skriðþungarúminu vegna áhrifa hljóðeinda og þéttist niður í lægstu orkuástöndin (bóseindir)

Segulflæðiskömmtun

$$\Phi_B = \frac{hc}{2e}$$

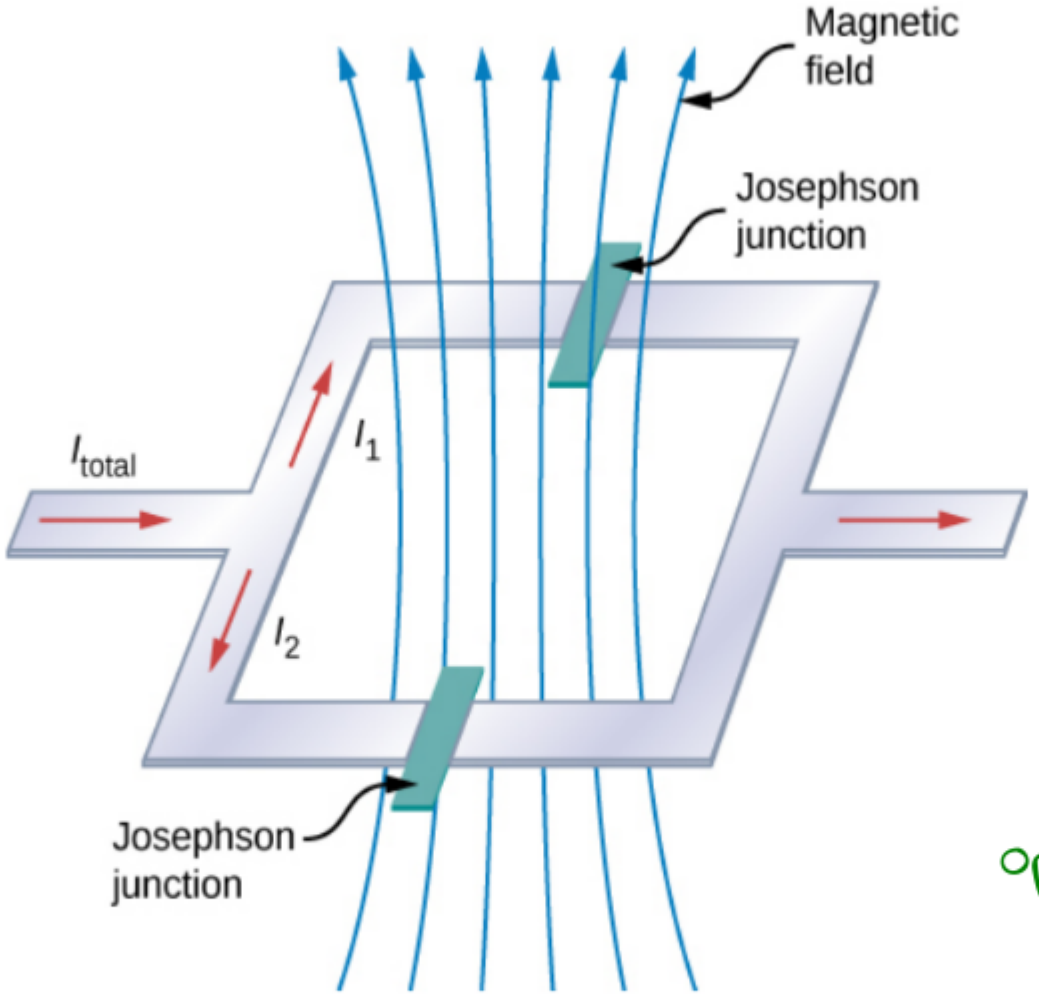


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Figure 9.29 The SQUID (superconducting quantum interference device) uses a superconducting current loop and two Josephson junctions to detect magnetic fields as low as 10^{-14} T (Earth's magnet field is on the order of 0.3×10^{-5} T).

Leiðni er líka skömmtuð $G_0 = \frac{2e}{h}$