Ex: For graphite, $\rho = 2,3\ g/cm^3$, $A = 12\ g/mol$. Find the number of atoms per cm^3

reminder: 1 mole = $6,023 \times 10^{23}$

$$n = \frac{N_{Av} \times \rho}{A} = \frac{6,023 \times 10^{22} \times 2,3\ g/cm^3}{12\ g/mol} = 11,5 \times 10^{22}\ atom/cm^3\ ?$$

Ex: Calculate the number of atoms in 100g of Ag. (Reminder: $A_{Ag} = 107,868\ g/mol$)

Number of in 100g Ag $\frac{100.(6,023.10^{23}\ atoms)}{107,868\ g/mol} = \underline{5,58.10^{23}}$ atoms

Ex: Consider an alloy of 75 wt% Cu and 25 wt% Ni. What are the atomic percentage of Cu and the atomic pertange of Ni of this material?

(For Cu, $A_{Cu} = 63,54\ g/mol$
For Ni, $A_{Ni} = 58,69\ g/mol$)

75 %wt Cu   25 %wt Ni

100g   75g Cu   25g Ni

$\frac{75g}{63,54g/mol} = 1,1803$ mol Cu $\frac{25\ g}{58,69g/mol} = 0,426$ mol Ni } Total = 1,606 mol

100 %   1,606 mol   100 %   1,606 mol

X %   1,1803 mol   X %   0,426 mol

Cu = 73,5 at %   Ni = 26,5 at %

Ex: F (4.0) F (4.0) Find the EN difference

$4.0 - 4.0 = 0$ 0.0 ~ 0,4 ⇒ Non-polar covalent

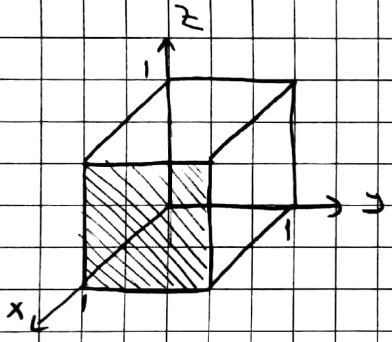
Ex: O (3,5) F (4,0) Find the EN difference

$4,0 - 3,5 = 0,5$ 0,4 ~ 2,0 then it is polar covalent

Ex: Ca (1,0) O (3,5) Find the EN difference

$3,5 - 1,0 = 2,5$ > 2,0 then it is ionic bond (−) (+)

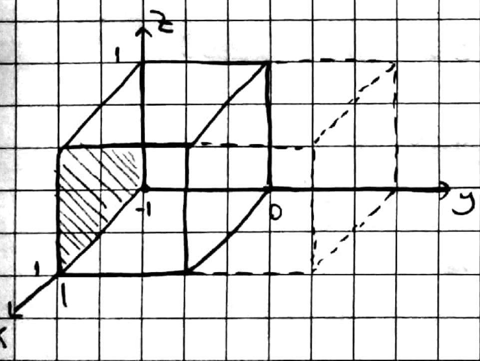
Ex:



	x	y	z
intercepts	1	∞	∞
reciprocals	$\frac{1}{1}$	$\frac{1}{\infty}$	$\frac{1}{\infty}$
reduce the fraction	1	0	0

Miller indices (1 0 0)

Ex:



x	y	z
∞	-1	∞
$\frac{1}{\infty}$	$\frac{1}{-1}$	$\frac{1}{\infty}$
0	-1	0

→ − olduğu için

Miller indices $(0\,\bar{1}\,0)$

Ex: A current density of 100,000 A/cm^2 is applied to a gold wire 50m long. The resistance of the wire found to be 2 Ω. Calculate the voltage applied to the wire, and calculate the diameter of the wire.

$$\left(\begin{array}{l}\sigma_{Au} = 4,26 \times 10^{5}\ \Omega^{-1} m^{-1} \\ \pi = 3,14\end{array}\right) \qquad J = \frac{I}{A} = \sigma \cdot \frac{V}{l} \qquad E = \frac{V}{l} \qquad J = \sigma \cdot E$$

$$100000 = 4,26 \cdot 10^{5} \cdot \frac{V}{50} \qquad \boxed{V = 11,74\ V}$$

$$I = \frac{V}{R} = \frac{11,74}{2} = 5,87\ A \qquad A = \frac{I}{J} = \frac{5,87}{100000} = 5,87 \cdot 10^{-5}\ cm^{2}$$

$$A = \pi r^{2} \Rightarrow r = 0,00432\ m$$

$$d = 2r = 8,64 \cdot 10^{-3}\ cm$$

Ex: Choose a suitable material from the table below for an electrical transmission line of 1500m long that will carry a current of 50 A with no more than 5.10^5 W power loss.

	σ ($\Omega^{-1}m^{-1}$)	d Density ($Mg.m^{-3}$)	Price (TL/tonne)
Aluminum	$3,77.10^7$	2,7	600
Copper	$5,98.10^7$	8,93	8500
Silver	$6,8.10^7$	10,49	480000

(1Mg = 1 tonne)

$P = I.V = I^2.R \Rightarrow R = \frac{P}{I^2} = \frac{5.10^5}{50^2} = 200\Omega$ $R = \rho.\frac{l}{A}$ $\sigma = \frac{1}{\rho}$

$A = \frac{l}{R.\sigma} = \frac{1500}{200.\sigma} = \frac{7,5}{\sigma}$

$A_{Al} = \frac{7,5}{3,77.10^7} = 0,199\ mm^2$ $A_{Cu} = \frac{7,5}{5,98.10^7} = 0,125\ mm^2$ $A_{Ag} = \frac{7,5}{6,8.10^7} = 0,11\ mm^2$

Weight of Al = A.l.d = $8,06.10^{-4}$ tonnes

cost Al = $8,06.10^{-4}$. 6000 = 4,83 TL

Weight of Cu = A.l.d = $1,67.10^{-3}$ tonnes

cost Cu = 14,195 TL

Weight of Ag = A.l.d = $1,73.10^{-3}$ tones

cost Ag = 847,7 TL

Based on this analysis, Al is the most economical choice even though it has longe diameter.

EX: Calculate the electrical conductivity of pure copper at

a) 400 °C b) -100 °C

ρ: resistivity at a temperature (T)

reminders: Resistivity of copper at 25 °C $1,67.10^{-8}$ Ωm

The temperature resistivity coefficient $\alpha = 0,0068\ °C^{-1}$

At 400 °C

$\rho = \rho_0 [1+\alpha(T-T_0)]$ $\rho = (1,67.10^{-8})[[1+0,0068(400-25)]]$

$\rho = 5,929.10^{-8}$ Ω

$\sigma = \frac{1}{\rho} = \underline{\underline{1,69.10^{7}\ \Omega^{-1}.m^{-1}}}$

At -100 °C

$\rho = (1,67.10^{-8})[[1+0,0068(-100-25)]]$ $\rho = 0,251.10^{-8}$ Ω $\underline{\underline{\sigma = 39,8.10^{7}\ \Omega^{-1}.m^{-1}}}$

Ex: For germanium at 25 °C estimate

a) the number of charge carries

b) the constant, n_0

Reminders: $\sigma = 2,0\ \Omega^{-1}m^{-1}$

$E_g = 0,67$ eV

Mobility ← $\mu_e = 0,38\ m^2 V^{-1}s^{-1}$

$\mu_h = 0,18\ m^2 V^{-1}s^{-1}$

$2kT = 0,0514$ eV at 25 °C

Boltzman Constant →

$q = 1,6.10^{-19}$ C

a) $\sigma = n.q.(\mu_e+\mu_h)$ $n = \frac{2,0}{(1,6.10^{-19})(0,38+0,18)} = 2,2.10^{19}$ carries/m^3

b) $n = n_0 . \exp\left(-\frac{E_g}{2kT}\right)$ $n_0 = \frac{2,2.10^{19}}{\exp\underbrace{(-0,67/0,0514)}} = 1,01.10^{25}$ carries/m^3

$e^{\boxed{}}$

Ex: For Si, if the conductivity is $5.10^{-6}\ \Omega^{-1}cm^{-1}$ at 25°C. Calculate the temperature required to double the electrical conductivity.

Reminders: $\mu_e : 1900\ cm^2V^{-1}s^{-1}$

$\mu_h : 500\ cm^2V^{-1}s^{-1}$

$n_0 : 2,835.10^{19}$ carries/cm^3

$k : 8,63.10^{-5}\ e.V.K^{-1}$ (Change to °C)

$q : 1,6.10^{-19}\ C$

$E_g : 1,107\ eV$

$\sigma : 5.10^{-6}\ \Omega^{-1}cm^{-1}$ at 25°C

$\sigma = n.q(\mu_e + \mu_h)$

$2.(5.10^{-6}) = n.(1,6.10^{-19})(1900+500) \Rightarrow n = 2,604.10^{10}$

$n = n_0.\exp\left(-\frac{E_g}{2kT}\right)$ $\quad 2,604.10^{10} = 2,835.10^{19}.\exp\left(-\frac{1,107}{2.8,63.10^{-5}.T}\right)$

$\ln(8,934.10^{-10}) = \left(\exp\left(-\frac{1,107}{1,726.10^{-4}T}\right)\right)\ln \Rightarrow -20,8228 = -\frac{1,107}{1,726.10^{-4}T}$

$T = 307,92\ K = 307,92 - 273 = \underline{\underline{34,92\ °C}}$

Ex: In order to keep the resistance of a copper wire to $0,5\ \Omega$ where the length is 30m. How long the radius of the wire should be?
$(\rho = 1,68.10^{-8}\ \Omega m)$

$R = \rho\frac{l}{A}$ $\quad A = \rho.\frac{l}{R}$ $\quad A = 1,008.10^{-6}\ m^2$ $\quad A = \pi r^2 \Rightarrow \underline{\underline{r = 5,66.10^{-4}\ m}}$

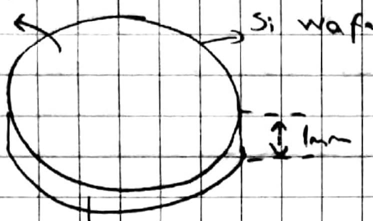
Ex: Suppose a silicon wafer 1 mm thick, which originally contain 1 phosphorus atoms for every 10 million silicon atom, is treated so that there are 400 phosphorus atoms for every 10 million silicon atoms at the surface.

Calculate the concentration gradient in atomic percent. m^{-1}.

$C_{surface} = \frac{400 P}{10^7 Si}$

↓

After doping of phosphour



$C_{initial} = \frac{1 P}{10^7 Si}$

$\text{Concentration gradient} = \frac{\Delta C}{\Delta x}$

$C_I = \frac{1}{10^7} \cdot 100 = 0,00001 \text{ at \% } P$

$C_{surface} = \frac{400}{10^7} \cdot 100 = 0,004 \text{ at \% } P$

$$\text{Concentration gradient} = \frac{(0,00001 - 0,004) \text{ at\% } P}{0,001 \text{ m}} = \underline{-3,99 \text{ at \% } P \cdot m^{-1}}$$

Ex. When a Cu-Zn alloy solidifies, one portion of structure contains 25 atomic percent Zinc and another portion, 0,025 mm away, 20 atomic percent Zinc. Determine the concentration gradient.

a) In atomic percent Zn per cm.

b) In weight percent Zn per cm.

(Reminder: Atomic mass of Zn = 65,38 g/mol
Atomic mass of Cu = 63,54 g/mol)

a) $\frac{\Delta c}{\Delta x} = \frac{20 \text{ at \%} - 25 \text{ at \%}}{(0,0025 \text{ cm})} = -2000 \text{ at \% } Zn \cdot cm^{-1}$

b) We need to define the wt % of each portion.

$$\text{wt \% } Zn_{P_1} = \frac{20 \cdot 65,38}{20 \cdot (65,38) + 80 \cdot (63,54)} = 20,46 \text{ wt \% } Zn$$

$$\text{wt \% } Zn_{P_2} = \frac{25 \cdot 65,38}{25 \cdot (65,38) + 75 (63,54)} = 25,54 \text{ wt \% } Zn$$

$$\frac{\Delta c}{\Delta x} = \frac{20,46 \% - 25,54 \%}{0,0025 \text{ cm}} = -2032 \text{ wt\% } Zn \, cm^{-1}$$

Ex: Consider a diffusion couple, set up between pure tungsten and a tungsten -1 at% thorium alloy. After several minutes of exposure at 2000 °C, a transition zone of 0,1 mm thickness is establised, what is the flux of thorium atoms at this time if $D_0 = 1,00 \times 10^{-4}$, $Q = 502300$ j/mol for thorium, in tungsten. And the number of tungsten atoms is $6,3.10^{28}$ atoms m^{-3}, $R = 8,314$ j/mol K

the number of thorium atoms, $C_{thorium} = (0,01).(6,3.10^{28}) = 6,3.10^{26}$ atoms m^{-3}

in pure tungsten the number thorium atoms is zero.

$$\text{Thus} \quad \frac{\Delta c}{\Delta x} = \frac{0 - 6,3.10^{26}}{0,1.10^{-3}} = -6,3.10^{30} \text{ atoms } m^{-3}.m^{-1}$$

$$D = D_0 . \exp\left(-\frac{Q}{RT}\right) = 1,0.10^{-4}.\exp\left(-\frac{502300}{8,314.2273}\right) \Rightarrow D = 2,86.10^{-16}\ m^2\ s^{-1}$$

↳ Kelvin C+273

$$J = -D.\frac{\Delta c}{\Delta x} \qquad J = 18,0.10^{14} \text{ Th atoms } m^2.s^{-1}$$

Ex: A parallel plate capacitor by two metal plates, each area of $\overset{0,014}{\overline{140\ cm^2}}$, seperated by vacuum, and gap between plates is $d = \overset{0,006m}{0,6}$ cm. What is the capacitance of this device? What potential difference must be applied between plates if the capacitor is to hold a charge of $Q = 0,8.10^{-3}\ \underset{10^{-6}}{\mu C}$ on each plate? ($\varepsilon_0 = 8,85.10^{-12}$ F/m)

$$C_0 = \frac{\varepsilon_0 . A}{d} = 8,85.10^{-12} . \frac{0,014}{0,006} = \underline{\underline{20,65\,pF}}$$

$$D_0 = \frac{Q_0}{A} = 5,714.10^{-8} \longrightarrow D_0 = \frac{C_0 . V}{A} \Rightarrow \underline{\underline{V = 38,74V}}$$

Ex: Consider two insulator material, tested with breakdown experiment. Results is as following;

1. material breakdown 20 kV when the distance of plates was $d_1 = 0,2$ cm $= 0,002$ m
2. material breakdown 250 kV when tha distance of plates was $d_2 = 0,1$ cm $= 0,001$ m

Which material you would choose for your high voltage application?

$$E_{d_1} = \frac{V_{d_1}}{d_1} = \frac{20}{0,2} = 100 \text{ kV/cm}$$

$$E_{d_2} = \frac{V_{d_2}}{d_2} = \frac{15}{0,1} = 150 \text{ kV/cm}$$

$E_{d_2} > E_{d_1}$ so the 2. material would be better to choose.

Ex: A condenser system has $C = 100$ pF $V = 100$ V with $f = 1$ MHz and active loss power of $P_a = 10^{-3}$ W. Find the reactive power and loss tangent. ($\pi = 3,14$)

$$P_a = \underbrace{V^2 . 2\pi f C}_{\text{reactive Power } (P_r)} . \tan\delta \qquad \tan\delta = \frac{P_a}{P_r} \qquad X_c = \frac{1}{2\pi f C}$$

$$10^{-3} = 100^2 . 2\pi f C . \tan\delta$$

$$P_r = 100^2 . 2\pi . f . C = 6,28 \text{ VAr}$$

$$\tan\delta = \frac{10^{-3}}{100^2 . 2 . 3,14 . 1.10^6 . 100.10^{-12}}$$

$$\tan\delta = 1,6.10^{-14}$$

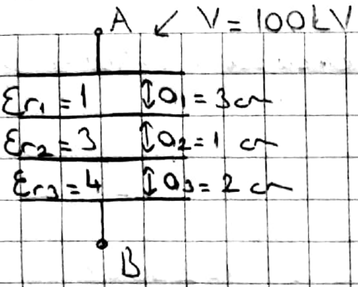
Ex: A parallel plate capacitor with the surface area of $2 \times 1,5$ m² with separated distance at 3 mm ($0,003$ m). The gap between plates is filled with an insulator ($\varepsilon_r = 2$). When the capacitor is fully charged with 12V battery. What will be the charge on plates? ($\varepsilon_0 = 8,85.10^{-12}$)

$$D = \frac{Q}{A} \qquad D = \varepsilon_0 . \varepsilon_r \frac{V}{d} \qquad D = 8,85.10^{-12} . 2 . \frac{12}{0,003} = 7,08.10^{-8}$$

$$Q = D.A \Rightarrow Q = 1,062.10^{-7}$$

?

Ex:



Consider the system in figure

a) Find the potential and electrical fields on each layer.

b) Determine if the system would breakdown totally.

$E_{d_1} = 30 kV/cm$

$E_{d_2} = 80 kV/cm$

$E_{d_3} = 50 kV/cm$

$A_1 = A_2 = A_3$

$$K = \frac{a_1}{\varepsilon_1} + \frac{a_2}{\varepsilon_2} + \frac{a_3}{\varepsilon_3} = \frac{a_1}{\varepsilon_0 \cdot \varepsilon_{r_1}} + \frac{a_2}{\varepsilon_0 \cdot \varepsilon_{r_2}} + \frac{a_3}{\varepsilon_0 \cdot \varepsilon_{r_3}}$$

$$K = \underbrace{\left(\frac{a_1}{\varepsilon_{r_1}} + \frac{a_2}{\varepsilon_{r_2}} + \frac{a_3}{\varepsilon_{r_3}}\right)}_{K_r} \cdot \frac{1}{\varepsilon_0} \Rightarrow K = K_r \cdot \frac{1}{\varepsilon_0}$$

$$K_r = \frac{3}{1} + \frac{1}{3} + \frac{2}{4} = 3,833$$

$$V_1 = \frac{a_1}{\varepsilon_1} \cdot \frac{V}{K} = \frac{a_1}{\cancel{\varepsilon_0} \cdot \varepsilon_{r_1}} \cdot \frac{V}{K_r \cdot \frac{1}{\cancel{\varepsilon_0}}} = \frac{a_1}{\varepsilon_{r_1}} \cdot \frac{V}{K_r} = \frac{3}{1} \cdot \frac{100}{3,833} = 78,267 kV$$

$$E_1 = \frac{V_1}{a_1} = 26,089 kV/cm$$

$$V_2 = \frac{a_2}{\varepsilon_{r_2}} \cdot \frac{V}{K_r} = 8,696 kV$$

$$E_2 = \frac{V_2}{a_2} = 8,96 kV/cm$$

$$V_3 = \frac{a_3}{\varepsilon_{r_3}} \cdot \frac{V}{K_r} = 13,044 kV$$

$$E_3 = \frac{V_3}{a_3} = 6,522 kV/cm$$

$$\left.\begin{array}{l} E_1 < E_{d1} \\ E_2 < E_{d2} \\ E_3 < E_{d3} \end{array}\right\} \text{The system would not breakdown.}$$

Ex: Consider a seriesly structured 4-layered parallel plate electrode system. Dielectric constant and thickness of the layers;

$\varepsilon_{r_1} = 2$ $\varepsilon_{r_2} = 1$ $\varepsilon_{r_3} = 3$ $\varepsilon_{r_4} = 4$

applied voltage is $V = 200\,kV$

$a_1 = 1cm$ $a_2 = 2cm$ $a_3 = 1cm$ $a_4 = 4cm$

a) Find the electrical fields and potentials on each layer.

b) $E_{d_1} = 100\,kV/cm$ find out if the system would breakdown totally?

$E_{d_2} = 30\,kV/cm$

$E_{d_3} = 80\,kV/cm$

$E_{d_4} = 60\,kV/cm$

a) $K = \frac{a_1}{\varepsilon_1} + \frac{a_2}{\varepsilon_2} + \frac{a_3}{\varepsilon_3} + \frac{a_4}{\varepsilon_4} = \underbrace{\left(\frac{a_1}{\varepsilon_{r_1}} + \frac{a_2}{\varepsilon_{r_2}} + \frac{a_3}{\varepsilon_{r_3}} + \frac{a_4}{\varepsilon_{r_4}}\right)}_{K_r} \frac{1}{\varepsilon_0} \Rightarrow K = K_r \cdot \frac{1}{\varepsilon_0}$ $K_r = 3{,}833$

$$E_1 = \frac{V}{\varepsilon_1 \cdot K} = \frac{V}{\cancel{\varepsilon_0} \cdot \varepsilon_r \cdot K_r \frac{1}{\cancel{\varepsilon_0}}} = \frac{V}{\varepsilon_{r_1} \cdot K_r} = \frac{200}{2 \cdot 3{,}833} = 26{,}089\,kV/cm$$

$E_2 = \frac{V}{\varepsilon_{r_2} \cdot K_r} = 52{,}17\,kV/cm$ $E_3 = \frac{V}{\varepsilon_{r_3} \cdot K_r} = 17{,}39\,kV/cm$ $E_4 = \frac{V}{\varepsilon_{r_4} \cdot K_r} = 13{,}044\,kV/cm$

$E_1 < E_{d_1}$ ✓ $E_2 > E_{d_2} \Rightarrow$ 2. layer would breakdown $E_3 < E_{d_3}$ ✓ $E_4 < E_{d_4}$ ✓

b) $E_2 > E_{d_2}$ thus the second layer would breakdown and the total voltage would divide up to only 3 layers. In this case, we need to re-calculate for 3 layers.

$K_r = \frac{a_1}{\varepsilon_{r_1}} + \frac{a_2}{\varepsilon_{r_2}} + \frac{a_3}{\varepsilon_{r_3}} = 1{,}833$

$E_1 = \frac{V}{\varepsilon_{r_1} \cdot K_r} = 54{,}55\,kV/cm$

$E_3 = \frac{V}{\varepsilon_{r_3} \cdot K_r} = 36{,}37\,kV/cm$

$E_4 = \frac{V}{\varepsilon_{r_4} \cdot K_r} = 27{,}28\,kV/cm$

$\left.\begin{array}{l} E_1 < E_{d_1} \\ E_3 < E_{d_3} \\ E_4 < E_{d_4} \end{array}\right\}$ Thus, the system would not breakdown totally. However, due to the breakdown of second layer, the system is weakened.

Ex: An Fe - 80% Ni alloys has a maximum relative permeability of 300000 when an inductance of 3500 Gauss is obtained. The alloys is placed in a 20-turn coil that is 2cm in length. What current must flow through the conductor to obtain this field?

$$\left(\begin{array}{l} 1 \text{ Tesla} = 10^4 \text{ Gauss} \\ \mu_0 = 4\pi \times 10^{-7} \text{ Wb/Am} \end{array} \right) \qquad \mu_r = \frac{\mu}{\mu_0} \Rightarrow 300000 = \frac{\mu}{4\pi 10^{-7}} \qquad \mu = 0{,}3768 \text{ Wb/Am}$$

$$H = \frac{B}{\mu} = \frac{3500/10}{0{,}3768} = 0{,}928 \text{ A/m}$$

$$H = \frac{n.I}{l} \Rightarrow I = \frac{H.l}{n} = \frac{(0{,}928 \text{ A/m})(0{,}02\text{m})}{20} \Rightarrow I = 0{,}00093 \text{ A}$$

Ex: To produce a solenoid coil that has an inductance of 2000 Gauss when a 10mA current flows through the conductor. The coil composed of 10-turns over a 1cm length. What would be the minimum relative permeability of material?

$1 \text{ Tesla} = 10^4 \text{ Gauss}$

$\mu_0 = 4\pi 10^{-7} \text{ Wb/Am}$

$$H = \frac{n.I}{l} = \frac{10.0{,}01\text{A}}{0{,}01\text{m}} = 10 \text{A/m}$$

$$\mu = \frac{B}{H} = \frac{2000/10^4}{10} = 0{,}02 \text{ Wb/Am}$$

$$\mu_r = \frac{\mu}{\mu_0} = \frac{0{,}02}{4\pi 10^{-7}} = 15923$$

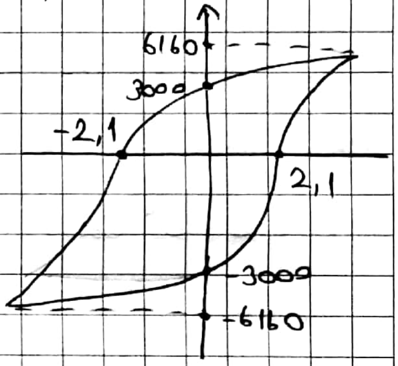
Ex: An Fe-49% Ni alloy has a maximum relative permeability of 6400 when a magnetic field of 9,947 A/m is applied. What inductance is obtained and what current is needed to obtain this inductance in 200-turn, 3cm long coil?

Reminder: $\mu = 4\pi\, 10^{-7}$ Wb/Am)

$\mu_r = \frac{\mu}{\mu_0} \Rightarrow \mu = 0{,}0804 \frac{Wb}{A.m}$ $\quad B = 7{,}997$ Tesla $\quad I = 1{,}49\ mA$

Ex: A magnetic material has a coersive field of 167 A/m, a saturation magnetization of 0,616 Tesla and a residual inductance of 0,3 Tesla. Sketch the hsteresis loop for the material in units of Gauss for B, and in Oersted for H=?

(Reminder
1 Tesla $= 10^4$ Gauss
1 A/m $= 4\pi\, 10^{-3}$ Oe)



$B_{saturation} = 0{,}616$ Tesla $= 6160$ Gauss

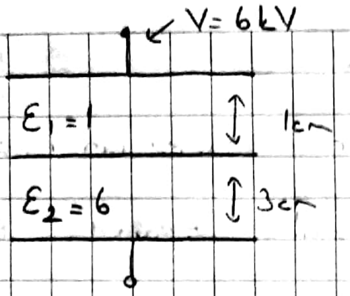
$B_r = 0{,}3$ Tesla $= 3000$ Gauss $\quad H_c = 167\ A/m \cdot 4\pi\, 10^{-3}\ Oe/Am^{-1}$
↳ resival

$\underline{H_c = 2{,}1 Oe}$

Ex: Calculate the fore in kN for one square meter area of a permanent magnet with a saturation magnetization of 1,61 Tesla

$$F = \frac{\mu_0 . M^2 . A}{2} = \frac{(\mu_0 . M)^2 . A}{2\mu_0} = \frac{(1{,}61)^2 . A}{2(4\pi . 10^{-7})} \qquad \frac{F}{A} = 1031{,}4 \frac{kN}{m^2}$$

Ex:

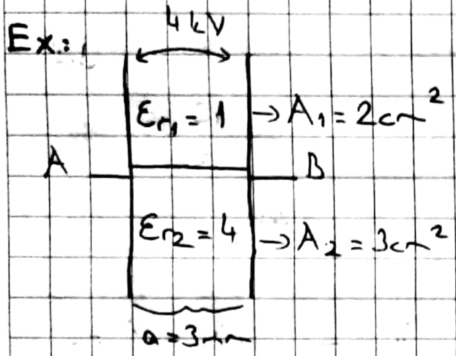


find the electric field on each insulator. $E_1 = ?$ $E_2 = ?$

$$E_1 = \frac{V}{a_1 + \frac{\varepsilon_1}{\varepsilon_2} \cdot a_2} = \frac{6000}{1 + \frac{1}{6} \cdot 3} = 4000 \text{ V/cm}$$

$$E_2 = \frac{V}{a_2 + \frac{\varepsilon_2}{\varepsilon_1} \cdot a_1} = \frac{6000}{3 + 6.1} = 666,66 \text{ V/cm}$$

Ex:



A parallel structured condencer system with two electries is given figure

a) Find the capacitance of each layer and equivalent capacitance in pF.

b) Find the electrical field on each layer and find the surface change density.

$(\varepsilon_0 = 8,85 . 10^{-12} F/m)$

a) $$C_1 = \frac{\varepsilon_1 . A_1}{a_1} = \frac{\varepsilon_0 . \varepsilon_r . A_1}{a_1} = \frac{8,85 . 10^{-12} . 1 . 2 . 10^{-4}}{3 . 10^{-3}} = 5,9 . 10^{-13} = 0,59 \text{ pF}$$

$$C_2 = \frac{\varepsilon_2 . A_2}{a_2} = \frac{\varepsilon_0 . \varepsilon_r . A_2}{a_2} = \frac{8,85 . 10^{-12} . 4 . 3 . 10^{-4}}{3 . 10^{-3}} = 3,54 \text{ pF}$$

$$C_{es} = C_1 + C_2 = 0,59 + 3,54 = 4,13 \text{ pF}$$

b) $$E_1 = E_2 = \frac{V}{a} = \frac{4 \text{ kV}}{0,3 \text{ cm}} = 13,33 \text{ kV/cm} = 13,33 . 10^5 \text{ kV/m}$$

$$D_1 = \varepsilon_1 . E_1 = \varepsilon_0 . \varepsilon_{r_1} . E_1 = 8,85 . 10^{-12} . 1 . 13,33 . 10^5 = 1,18 . 10^{-5} \text{ C/m}^2$$

$$D_2 = \varepsilon_2 . E_2 = \varepsilon_0 . \varepsilon_{r_2} . E_2 = 8,85 . 10^{-12} . 4 . 13,33 . 10^5 = 4,72 . 10^{-5} \text{ C/m}^2$$