OS 1

a) $C = \varepsilon \cdot \frac{A}{d} \Rightarrow \varepsilon = C \cdot \frac{d}{A}$

$\varepsilon = 43.8 \cdot 10^{-12} \cdot \frac{0.01}{\pi \cdot 0.05^2} = 5,578 \cdot 10^{-11}$

$\varepsilon = \varepsilon_r \cdot \varepsilon_0 \Rightarrow \varepsilon_r = \frac{\varepsilon}{\varepsilon_0} = \frac{5,578 \cdot 10^{-11}}{8,85 \cdot 10^{-12}} = \underline{6,30}$

b) $s = 20\,mm \Rightarrow U = 59,0\,kV$

$R = U/I = 59000 / 12 \cdot 10^{-12} = 4,92 \cdot 10^{15}\,\Omega$

$R = \rho \frac{d}{A} \Rightarrow \rho = R \frac{A}{d} = 4,92 \cdot 10^{15} \frac{\pi \cdot 0,05^2}{0,01} =$

$3,86 \cdot 10^{15}$ $\rho = 3,86 \cdot 10^{15}\,\Omega$ $\Rightarrow$ $\sigma_0 = \frac{1}{\rho} = \frac{1}{3,86 \cdot 10^{15}} = \underline{2,59^{-16}\,\frac{S}{m}}$

c) (7.33) $\omega C_4 R_4 = \tan \delta_x$

$2\pi \cdot 50 \cdot 300 \cdot 10^{-9} \cdot \frac{1000}{\pi} = 0,03 \Rightarrow \underline{\delta_x = 1.72^\circ}$

d) $\tan\delta = \frac{\varepsilon_r'' + \sigma_0/\varepsilon_0 \cdot \omega}{\varepsilon_r'} \Rightarrow$

$\varepsilon_r' \cdot \tan\delta = \varepsilon_r'' + \sigma_0/\varepsilon_0 \omega \Rightarrow \varepsilon_r'' = \varepsilon_r' \tan\delta - \sigma_0/\varepsilon_0 \omega$

$\varepsilon_r'' = 6.3 \cdot 0.03 - \frac{2,59 \cdot 10^{-16}}{8,85 \cdot 10^{-12} \cdot 2\pi 50} = 0,183$

$\underline{\tilde{\varepsilon}_r} = \tilde{\varepsilon}_r' + j\tilde{\varepsilon}_r''$, where $\tilde{\varepsilon}_r'' = \varepsilon_r'' + \sigma_0/\varepsilon_0 \omega$

$\underline{\tilde{\varepsilon}_r} = 6.30 + j\left(1.89 + 2.59 \cdot 10^{-16} / 8.85 \cdot 10^{-12}\, 2\pi 50\right)$

$\underline{\tilde{\varepsilon}_r} \cong 6.30 + j\,1.89$

- 6.30: CAPACITANCE
- 1.89: POLARISATION
- $2.59 \cdot 10^{-16} / 8.85 \cdot 10^{-12}\, 2\pi 50$: SMALL CONDUCTIVE PART
- 1.89: LOSSES (CONDUCTION / POLARISATION)

c/ $P_{diel} = \omega C \tan\delta U^2$

$E = 8\ kV/mm \Rightarrow U = 80\ kV$

$P_{diel} = 2\pi 50 \cdot 4/3{,}8 \cdot 10^{-11} \cdot 0{,}03 \cdot 80000^2 = 2{,}64\ W$

$P_{diel\ spec.} = P_{diel}/V = 2{,}64 / \pi \cdot 5^2 \cdot 1 = 33{,}6\ mW/cm^3$

Oj 2 Series Impedance reflected

a/ $X_C = 1/\omega C = 1/2\pi 50 \cdot 0{,}25 \cdot 10^{-6} \cdot 55 = 231{,}5\,\Omega$

$1{,}3 \cdot 245\,kV = 318\,kV$ test voltage.

$I = 73000/231{,}5 = 137\,A$

$Q = I^2 \cdot X_L = 137^2 \cdot 231{,}5 = \underline{438\,MW}$

Very high power, just like real power transformer, not practical for testing!

b/ Fig 2.20 p. 45

$\omega_0 = 1/\sqrt{LC} \Rightarrow L = \dfrac{1}{\omega^2 C}$

$L_{30Hz} = \dfrac{1}{(2\pi 30)^2 \cdot 0{,}25 \cdot 10^{-6} \cdot 55} = \underline{2{,}05\,H}$

$L_{200Hz} = \underline{416\,mH}$

c/ $Q = \dfrac{\omega L}{R}$, $200 = \dfrac{2\pi \cdot 30 \cdot 2{,}05}{R}$

$R_{30Hz} = 1{,}53\,\Omega$, $R_{200Hz} = 0{,}290\,\Omega$

Resonance $\Rightarrow |V_C| - |V_L| = Q \cdot |V_s| \Rightarrow$

$318 = 200 \cdot |V_s| \Rightarrow |V_s| = \underline{1{,}59\,kV}$

$I_{30Hz} = \dfrac{V_s}{R_{30}} = \dfrac{1590}{1{,}93} = \underline{824\,A}$

$P_{30Hz} = I_{30}^2 \cdot R_{30} = 824^2 \cdot 1{,}93 = \underline{1{,}31\,MW}$

$$I_{200Hz} = \frac{V_s}{R_{200}} = \frac{1590}{0.290} = \underline{5494\,A}$$

$$P_{200_{1m}} = 5494^2 \cdot 0.290 = \underline{8.7\,mW}$$

d/ See c/ We need 8.7 mW at 200 Hz but only 1.31 mW at 30 Hz