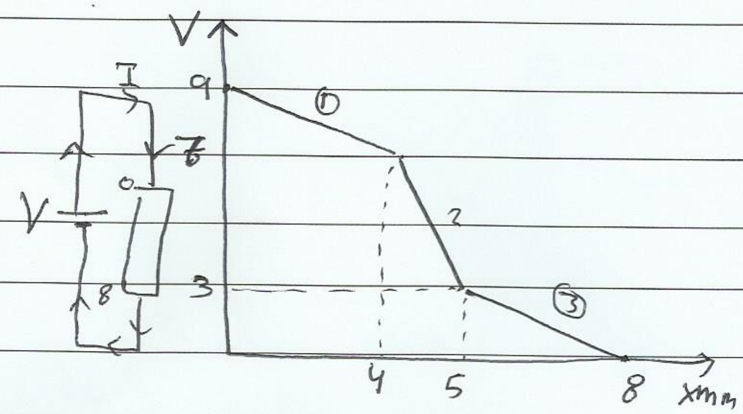
(26-4)

$E = \rho J$ OHM'S Law

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



$E_3 = -\frac{\Delta V}{\Delta X} = \frac{-(0-3)}{(8-5)10^{-3}} = \frac{3}{3} \times 10^{3}$

$E_3 = 1000\, V/m$

$J_3 = \sigma_3 E_3 = 4\times10^{7}(1\times10^{3}) = 4\times10^{10}\ A/m^2$

$J_3 = J_2 = J_1$ → the same current in series
↳ the same cross sectional area.

$E_1 = -\frac{\Delta V}{\Delta X} = (-)\frac{7-9}{(4-0)10^{-3}} = \frac{2}{4}\times10^{3} = 500\, V/m$

$\sigma_1 = \frac{J_1}{E_1} = \frac{4\times10^{10}}{500} = 8\times10^{7}\ (\Omega.m)^{-1}$

$E_2 = -\frac{\Delta V}{\Delta x} = (-)\frac{3-7}{(5-4)10^{-3}} = 4\times10^{3}\ V/m$

$\sigma_2 = \frac{J_2}{E_2} = \frac{4\times10^{10}}{4\times10^{3}} = 10^{7}\ (\Omega.m)^{-1}$

(26-13) $\sigma = 2\times10^{6}\ (\Omega.m)^{-1}$

$A = 2.3\ mm^2$

$I = 5.5A$

$V = 1.4V$ } ⇒ $R = \frac{V}{I} = \frac{1.4}{5.5} = 0.255\ \Omega$

$L = ?$

$R = \frac{\rho L}{A} = \frac{L}{\sigma A}$

$L = \sigma A R$

$= (2\times10^{6})(2.3\times10^{-6})(0.255)$

$= 1.17 m$

(26-25) $L_C = L_D = 1.0m$

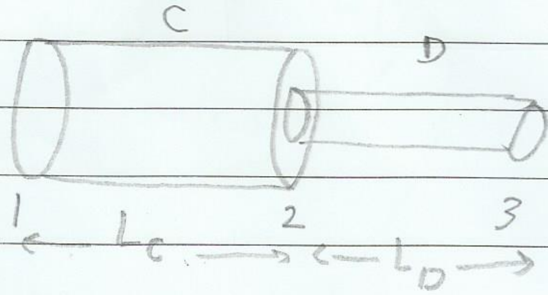
$\rho_C = 2\times10^{-6}\ \Omega\cdot m$, $r_C = 1mm$

$\rho_D = 1\times10^{-6}\ \Omega\cdot m$, $r_D = 0.5mm$

$I = 2A$

Find ΔV_C, ΔV_D ?

P_C, P_D ?



$R = \rho L / A$

$$R_C = \frac{(2\times10^{-6})(1)}{\pi(1\times10^{-3})^2} = 0.64\ \Omega$$

$$\Delta V_C (V_2 - V_1) = IR_C = 2(0.64) = \underline{1.27\ V}$$

$$P_C = P_{12} = I^2 R_C = (2)^2[0.64] = \underline{2.56\ Watt}$$

$$R_D = \frac{\rho_D L_D}{A_D} = \frac{(1\times10^{-6})(1)}{\pi(0.5\times10^{-3})^2} = 1.27\ \Omega$$

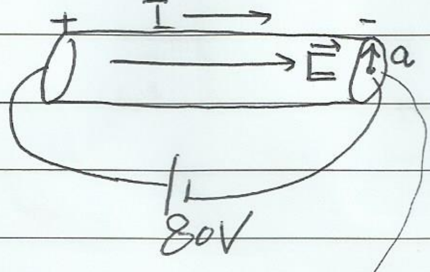
$$\Delta V_D = V_3 - V_2 = IR_D = 2(1.27) = \underline{2.55\ V}$$

$$P_D = P_{23} = I^2 R_D = (2)^2[1.27] = \underline{5.08\ Watt}$$

(26-32) $J = (2.75 \times 10^{10}) r^2$, $R = 3\,mm$

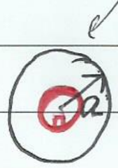
$J = \alpha r^2$, $\alpha = 2.75 \times 10^{10}\ A/m^4$

How much energy is converted to thermat energy in 1h?



$P_R = IV$, $U = IV\,time$

We have to find I



$I = \int \vec{J} \cdot d\vec{A}$, $dA = 2\pi r dr$

$= \int_0^a \alpha r^2 (2\pi r dr) = 2\pi\alpha \int_0^a r^3 dr = 2\pi\alpha \left[\frac{r^4}{4}\right]_0^a$

$= \frac{\pi\alpha}{2} R^4 = \frac{3.14 \times 2.75 \times 10^{10} (3 \times 10^{-3})^4}{2}$

$= 3.5\,A$

$P_R = IV$, $U = IV\,time$

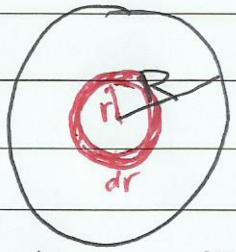
$P_R = 3.5(80) = 280\,Watt$

$U = P_R \cdot t = 280\left(1h \times \frac{3600s}{1h}\right) = 1.007 \times 10^6\ Watt$

$= 1.01 \times 10^6\ Watt \cdot s = 1.01 \times 10^6\ J$

~~$= 1.01 \times 10^3\ kJ$~~

(26-45) Radius = 2.67 mm



a) $J_a = J_0 r/R$, $J_0 = 5.50 \times 10^4 \ A/m^2$

$I = \int \vec{J} \cdot d\vec{A}$, $dA = 2\pi r\,dr$

$= \int_0^R \frac{J_0 r}{R}(2\pi r\,dr) = \frac{2\pi J_0}{R}\int_0^R r^2 dr = \frac{2\pi J_0}{R}\left[\frac{r^3}{3}\right]_0^R$

$I_a = \frac{2\pi J_0}{3R} R^3 = \frac{2\pi J_0 R^2}{3}$

$I_a = \frac{2(3.14) \times 5.5 \times 10^4 \times (2.67 \times 10^{-3})^2}{3} = 0.821 \ A$

b) $J_b = J_0\left(1 - \frac{r}{R}\right)$

$I_b = \int \vec{J} \cdot d\vec{A} = \int_0^R J_0\left(1 - \frac{r}{R}\right)(2\pi r\,dr$

$= 2\pi J_0 \int_0^R \left(r - \frac{r^2}{R}\right) dr = 2\pi J_0 \left[\frac{r^2}{2} - \frac{r^3}{3R}\right]_0^R$

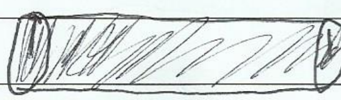
$= 2\pi J_0 \left[\frac{R^2}{2} - \frac{R^3}{3R}\right] = 2\pi J_0 \left[\frac{R^2}{2} - \frac{R^2}{3}\right]$

$= 2\pi J_0 R^2 \left[\frac{1}{6}\right] = \frac{\pi J_0 R^2}{3}$

$I_b = \frac{\pi J_0 R^2}{3} = 0.411 \ A$

c) Near the surface at $r = R$ $J_a > J_b$

(26-49)



$r_A = 1mm$

$r_1 = 1mm$
$r_2 = 2.2mm$

$$R_A = \frac{\rho L}{A} = \frac{\rho L}{\pi r_A^2} = \frac{\rho L}{\pi (1\times10^{-3})^2}$$

$$R_B = \frac{\rho L}{A} = \frac{\rho L}{\pi r_2^2 - \pi r_1^2} = \frac{\rho L}{\pi (r_2^2 - r_1^2)}$$

$$\frac{R_A}{R_B} = \frac{\rho L}{\pi r_A^2} \times \frac{\pi (r_2^2 - r_1^2)}{\rho L} = \frac{r_2^2 - r_1^2}{r_A^2}$$

$$= \frac{(2.2\times10^{-3})^2 - (1\times10^{-3})^2}{(1\times10^{-3})^2} = \frac{(2.2)^2 - (1)^2}{(1)^2} = 3.84$$

$$\frac{R_A}{R_B} = 3.84 \quad , \quad R_A = 3.84 R_B$$