Physics 161 | Problem Set #10 | R.V. Duncan, 4/4/06

Ex. 25.3: a) Cu: $n = 8.5\times10^{28}\, e^-/m^3$, $L = 0.710\,m$, $D = 2.05\times10^{-3}\,m$

$I = 4.85A = JA = n e v_d A$, so $v_d = \dfrac{4.85A}{(8.5\times10^{28}m^{-3})(1.6\times10^{-19}C)}\cdot\dfrac{1}{\frac{\pi}{4}(2.05\times10^{-3}m)^2} = \boxed{1.1\times10^{-4} m/s = 0.11\ mm/s.}$

Transit time $= \dfrac{0.710m}{0.108\times10^{-3} m/s} = 6.6\times10^3 s$ (almost 2 hours).

b) Same calculation, but with $D = 4.12\times10^{-3} m$.

$v_d = v_d(\text{part a})\cdot\left(\dfrac{2.05\times10^{-3}m}{4.12\times10^{-3}m}\right)^2 = 2.67\times10^{-5} m/s.$

so $T = \dfrac{0.710}{2.67\times10^{-5} m/s} = 2.66\times10^4 s = 440\ min. = \boxed{7.4\ hrs.}$

c) $v_d \sim \dfrac{1}{D^2}$, everything else held constant.

Ex. 25.17: a) $J_c = 1.0\times10^5\ A/cm^2$, $D(18\ gauge) = 1.02\times10^{-3} m$

$I_{max} = J_c A = J_c\cdot\frac{\pi}{4}D^2 =$ [illegible] $= \boxed{820 A.}$

b) $J_c = 1.0\times10^6 \frac{A}{cm^2}$, $I = 10^3 A$, so Area $= I/J_c = 1.0\times10^{-3}\ cm^2$

$D = \left(\dfrac{4A}{\pi}\right)^{1/2} = \boxed{3.6\times10^{-2}\ cm^2}$

Ex. 25.35: (See Figure 25.33 on p. 975): $V_{open} = 3.08V$, $V_{closed} = 2.97V$, $A = 1.65A$

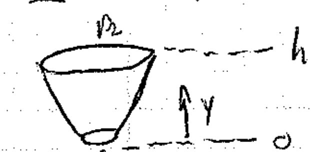
$V_{open} = \mathcal{E}$, $V_{closed} = \mathcal{E} - Ir$

So $V_{open} - V_{closed} = Ir = 0.11V$

hence $r = \dfrac{0.11V}{1.65A} = \boxed{0.067\,\Omega}$ $\quad \mathcal{E} = V_{open} = \boxed{3.08V}$

$R = V_{closed}/I = 2.97V/1.65A = \boxed{1.80\,\Omega}$

Ex. 25.43: $P = IV = (0.80A)(650V) = \boxed{520 W}$

Prob. 25.59: 

(See Figure 25.36, p. 977).

a) For each slice, $dR = \dfrac{\rho\, dy}{\pi r^2}$

Now $r(y) = r_1 + \dfrac{r_2-r_1}{h}y$, so $y = (r-r_1)\cdot\dfrac{h}{r_2-r_1}$

$dy = \dfrac{h}{r_2-r_1}dr$. $R = \int_0^h dR = \int_{r_1}^{r_2}\dfrac{\rho}{\pi}\cdot\dfrac{h}{r_2-r_1}\dfrac{dr}{r^2} = \dfrac{\rho}{\pi}\cdot\dfrac{h}{r_2-r_1}\cdot -\dfrac{1}{r}\Big|_{r_1}^{r_2}$

So $R = \frac{\rho}{\pi}\cdot\frac{h}{r_2-r_1}\cdot\left(\frac{1}{r_1}-\frac{1}{r_2}\right)\cdot\frac{r_1 r_2}{r_1 r_2} = \frac{\rho}{\pi}\frac{h\,(r_2-r_1)}{r_1 r_2\,(r_2-r_1)} = \boxed{\frac{\rho h}{\pi r_1 r_2}}$

b) when $r_1 = r_2 = r$, $R = \frac{\rho h}{\pi r^2} = \frac{\rho h}{A}$ ✓

Problem 25.66: $R = 10^4\,\Omega$, $V = 14.4\times10^3\,V$, $r = 2\times10^3\,\Omega$

a) $I = \frac{1.44\times10^4\,V}{10^4\,\Omega + 2\times10^3\,\Omega} = \boxed{1.2\,A}$ b) $P = I^2R = (1.2A)^2\cdot10^4\,\Omega = \boxed{1.4\times10^4\,W}$ (lethal!)

c) $I = 10^{-3}A = 1.00\,mA$, $R = r + 10^4\,\Omega$, so

$1.44\times10^4\,V = (1.00\times10^{-3}\,A)(10^4\,\Omega + r)$. so

$10^4\,\Omega + r = 1.44\times10^7\,\Omega$, so $\boxed{r = 1.44\times10^7\,\Omega}$

Extra Credit: C.P. 25.82: (See Figure 25.40, p. 979):

$2.00\,V = V_{diode} + I\cdot(1.00\,\Omega) \Rightarrow$

$2.00\,V = V + I[e^{eV/kT} - 1]\cdot 1\,\Omega$ $\boxed{2.00\,V - V = I_s[e^{eV/kT} - 1]}$

Now $I_s = 1.50\,mA$, $T = 293\,K$, so $I_s = 1.50\times10^{-3}\,A$,

$\frac{e}{kT} = \frac{1.60\times10^{-19}\,C}{(1.38\times10^{-23}\,J/K)(293\,K)} = 39.6\,V^{-1}$

So $(2.00\,V) - V = (1.50\times10^{-3}\,V)\left[e^{(39.6\,V^{-1})\cdot V} - 1\right]$

don't get confused. V is both the unit of volts and V is the variable that we are solving for! Bad notation. See ~~plot~~ table for the solution. Notice that the best value is $\boxed{V = 0.17935 \text{ Volts}}$

Problem Set #10, Cont'd.

V (volts)	2.00volts - V	Right-hand side (volts)	LHS-RHS (volts)
0	2	0	2
0.01	1.99	0.000728804	1.989271196
0.02	1.98	0.001811711	1.978188289
0.03	1.97	0.00342077	1.96657923
0.04	1.96	0.005811622	1.954188378
0.05	1.95	0.009364114	1.940635886
0.06	1.94	0.014642654	1.925357346
0.07	1.93	0.022485875	1.907514125
0.08	1.92	0.034139875	1.885860125
0.09	1.91	0.051456197	1.858543803
0.1	1.9	0.077185989	1.822814011
0.11	1.89	0.115417097	1.774582903
0.12	1.88	0.172223527	1.707776473
0.13	1.87	0.256630458	1.613369542
0.14	1.86	0.382048127	1.477951873
0.15	1.85	0.568402394	1.281597606
0.16	1.84	0.845300482	0.994699518
0.17	1.83	1.256734854	0.573265146
0.171	1.829	1.307560663	0.521439337
0.172	1.828	1.360439558	0.467560442
0.173	1.827	1.41545447	0.41154553
0.174	1.826	1.472691685	0.353308315
0.175	1.825	1.532240969	0.292759031
0.176	1.824	1.59419572	0.22980428
0.177	1.823	1.658653103	0.164346897
0.178	1.822	1.725714213	0.096285787
0.179	1.821	1.795484225	0.025515775
0.1791	1.8209	1.802614391	0.018285609
0.1792	1.8208	1.809772848	0.011027152
0.1793	1.8207	1.816959709	0.003740291
0.1794	1.8206	1.824175087	-0.003575087
0.1795	1.8205	1.831419094	-0.010919094

say $V = 0.17935 \pm .00005\ V$