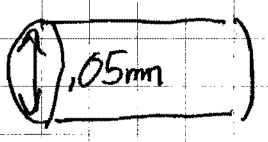
27.10



first assume the current is uniform and not a "skin effect" where the current ~~is~~ primarily at the wire's surface

$J \cdot A = I$

$V = IR$ w/ $V = 120\,V$ $R = 144\,\Omega$

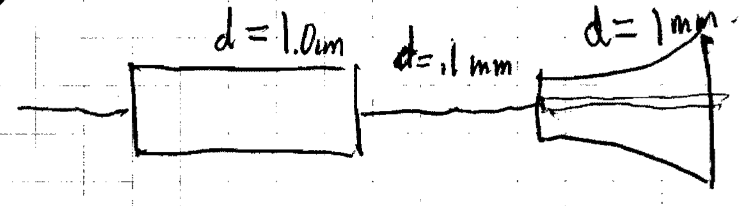
so $J = \frac{V}{\pi r^2 R}$

13 $\rho_e = 5.0\times10^{18}\,\frac{\text{electrons}}{m^3}$ $\rho_p = 5.0\times10^{18}\,\frac{\text{protons}}{m^3}$

a) $J = \rho_e(-e)V_e + \rho_p(e)V_p$

b) $\left|\frac{\cancel{\rho_e}\cancel{(-e)}V_e + \cancel{\rho_p}\overset{-1}{\cancel{(e)}}V_p}{\cancel{\rho_e}\cancel{(-e)}V_e}\right| = \left|\frac{V_e - V_p}{V_e}\right|$

14) $I = 100\,mA$



in copper $I = \rho_{electrons}(-e)V_{ec} \cdot A_{wire}$

$V_{ec} = \frac{I}{e(-e)\pi \frac{d_{wire}^2}{4}}$

I = constant

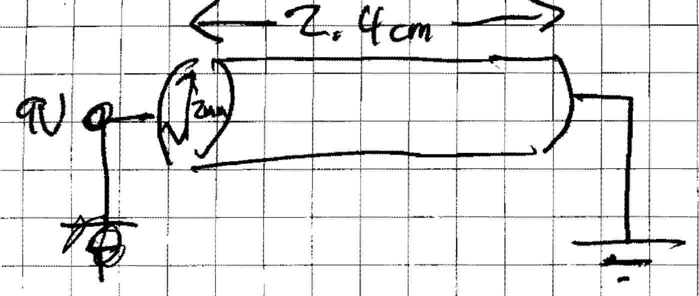
$J_1 A_1 = J_2 A_2 = J_3 A_3$

in solution you have two equally massive ions moving in opposite directions so whatever theirs velocities are the net velocity will be 0

in beam $I = \rho_{eb}(-e)V_{eb} \cdot A_{beam}$ $V_{eb} = \frac{I}{\rho_{eb}(-e)A_{beam}}$

note the minus sign is conditioned on direction of I which is not given

36)



$I = 2{,}6\,mA$

$$I = J\cdot A = \frac{E}{\rho_r}A = \frac{V}{l\rho_r}A$$

$$\rho_r = \frac{V}{I}\frac{A}{l} \quad \frac{9}{2{,}6\times10^{-3}}\;\frac{\pi(1\times10^{-3})^2}{.024} \approx \frac{30\times10^{-6}}{6.25\times10^{-5}} \approx \frac{3}{6} = \frac{1}{2}$$

so germanium

39) $R = \frac{\rho_r l}{A} \Rightarrow \frac{R}{l} = \frac{\rho_r}{A}$ $\quad\rho_{alum} = 2{,}65\times10^{-8}$

$\rho_{copper} = 1{,}68\times10^{-8}$

a) $\frac{R}{l} = 50\times10^{-6}\,\Omega/m = \frac{1{,}68\times10^{-8}}{\pi r^2}$

$d = 2r = 2\sqrt{\frac{1{,}68\times10^{-8}}{\pi\, 50\times10^{-6}}} \approx 2\sqrt{10^{-4}} = 2\times10^{-2}\,m = 2cm$

b) $d = 2\sqrt{\frac{2{,}65\times10^{-8}}{\pi 50\times10^{-6}}} = \sqrt{\frac{2.65}{1{,}68}}\,d_c \approx \frac{1{,}6}{1.3}d_c \approx 2.5\,cm$

c) cost of Al = \$1,34 /Kg $\quad$ cost of Cu = \$1,53 /Kg

$\rho_m = 2{,}7\,g/cm^3 = 2.7\times10^3\,Kg/m^3$ $\quad \rho = 8.9\,g/cm^3 = 8.9\times10^3\,Kg/m^3$

1 meter of wire has volume of $\pi\left(\frac{d}{2}\right)^2\cdot 1\ m^3$

though ultimately volume simply scales like $d^2 l$
so w/ $l = 4/\pi$ we get $V = d^2$

$d_{Al}\rho_{Al}C_{Al} = 6{,}25\times2.7\cdot1.34 \approx 18\times\frac{4}{3} = 24$ in arbitrary units

$d_{Cu}\rho_{Cu}C_{Cu} = 4\times8.9\times1.53 \approx 36\cdot\frac{3}{2} = 48$ in same units

so Al is about half the price (saying nothing about the increase cost of the heavier copper wire being held in the air)

50 $P = VI$ $\quad 1000\,MW = 120\,I$

$I = \frac{1000 \times 10^6}{120}$

note that the number of TV's is never invoked as each TV uses 1000 MW drawn from 120 V so each draws $\frac{1000 \times 10^6}{120}$ Amps

(note this power comes from discharging a capacitor not from a power plant at once)

71) $R = \frac{\rho l}{A}$ ~~$\neq$~~ $dR = \frac{\rho\, dx}{A(x)}$

A(x) can be found by noting r increase linearly from a to b as x goes from 0 to l

~~$r = a + \frac{b}{l}x$~~ $r =$

$A(x) = \pi r^2 = \pi\left(a + \frac{b-a}{l}x\right)^2$

$R = \int_0^l \frac{\rho\, dx}{\pi\left(a + \frac{b-a}{l}\right)^2} \Rightarrow \int_a^b \frac{\rho\, du}{\pi u^2}\frac{l}{b-a} = \frac{-\rho}{\pi u}\frac{l}{b-a}\Big|_a^b$

$u = a + \frac{a-b}{l}x$ $\quad$ note $u = r$

$du = \frac{a-b}{l}dx$

$= \frac{-\rho}{\pi b}\frac{l}{b-a} + \frac{\rho}{\pi a}\frac{l}{(b-a)}$

$= \frac{\cancel{(b-a)}}{\cancel{(b-a)}}\frac{\rho l}{\pi ab}$