1. Wire (7 pts)

1) Using the Ohm's law in differential form, $E = \rho j$, and noting that the electric field must be the same both in the core and in the coating, we conclude $j_c\rho_c = j_a\rho_a \Rightarrow j_c = æ_a\rho_a/\rho_c$. On the other hand, the net current $I = \frac{\pi}{4}[a^2 j_c + (b^2 - a^2)j_a] = \frac{\pi}{4} j_a(b^2 - a^2 + a^2\rho_a/\rho_c)$, hence

$$j_a = \frac{4}{\pi}\frac{I}{b^2 + a^2(\rho_a - \rho_c)/\rho_c} \approx 0.15\,\mathrm{A/mm^2}; \quad j_c \approx 0.25\,\mathrm{A/mm^2}.$$

2) Writing down the circulation theorem for a circular concentric loop of radius c around the straight wire, $2\pi c B_1 = \mu_0 I$, we obtain

$$B_1 = \frac{\mu_0 I}{2\pi c} = 2\frac{I}{c}\cdot 10^{-7}\,\mathrm{H\cdot m^{-1}} = 4.8\cdot 10^{-5}\,\mathrm{T}.$$

3) Using the technique as before, but noting that the current flowing through the smaller loop of radius $a/2$ is $I_c = j_c\frac{\pi}{4}a^2$, we obtain

$$B_2 = \frac{\mu_0 I_c}{\pi a} = \frac{\mu_0 j_c a}{4} = \pi j_c a\cdot 10^{-7}\,\mathrm{H\cdot m^{-1}} = 2.0\cdot 10^{-4}\,\mathrm{T}.$$