

4.2 (a) A cylindrical wire of thermal conductivity κ , radius a and resistivity ρ uniformly carries a current I . The temperature of its surface is fixed at T_0 using water cooling. Show that the temperature $T(r)$ inside the wire at radius r is given by

$$T(r) = T_0 + \frac{\rho I^2}{4\pi^2 a^4 \kappa} (a^2 - r^2).$$

(b) The wire is now placed in air at temperature T_{air} and the wire loses heat from its surface according to Newton's law of cooling (so that the heat flux from the surface of the wire is given by $\alpha(T(a) - T_{\text{air}})$ where α is a constant. Find the temperature $T(r)$.