Solution to Q.No. 39

Consider a vertical surface at a distance x from a and one more surface at a small distance dx from this surface. The volume between these two is a small resistor. The area of this surface is:

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

Therefore its resistance is dR = p*dx/A

Now, when x becomes l_1, the superconductor part starts. From l_1 to l_2, it remains. This part can be considered as two resistors connected in parallel – the superconductor is one resistor and the remaining portion is the other. The superconductor has zero resistance. When two resistors are connected in parallel with one of them being zero, then the equivalent resistance becomes zero. So from l_1 to l_2 there is no resistance. And the remaining part of the truncated cone can be considered as many small resistors of thickness dx connected in series. So the overall resistance is:-

$$R = \int_0^{l_1} \frac{\rho}{\pi\left[(b-a)\frac{x}{l} + a\right]^2} dx + \int_{l_2}^{l} \frac{\rho}{\pi\left[(b-a)\frac{x}{l} + a\right]^2} dx$$

$$= \frac{\rho l}{\pi k}\left(\frac{k}{ab} + \frac{1}{a + \frac{l_2}{l}k} - \frac{1}{a + \frac{l_1}{l}k}\right)$$

where, k =b – a

Note that as $l_2 \to l_1$, $R \to \frac{\rho l}{\pi ab}$ which is a well-known result.