Exercise 18

Introduction to Electrodynamics

ISBN: 9780321856562

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Solution Verified

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Refer to the Figure 7.29). The induced electric field will be in the positive z-direction, and will fall off as $\ln s^{-1}$, so the current will flow **anticlockwise**. Now, by Faraday's law:

$$\begin{aligned}\mathcal{E} &= -\frac{d\Phi}{dt} = -\frac{d}{dt}\int_0^a \int_s^{a+s} \frac{\mu_0}{2\pi s}(1-\alpha t) I\, ds\, dz \\ &= \frac{\mu_0 \alpha I}{2\pi} a \ln \frac{a+s}{s}\end{aligned}$$

Then, since $I = \dot{Q}$:

$$\frac{dQ}{dt} = \frac{\mathcal{E}}{R} = \frac{\mu_0 \alpha I}{2\pi R} a \ln \frac{a+s}{s}$$

$$\implies \Delta Q = \int_0^{1/\alpha} \frac{\mathcal{E}}{R} dt = \boxed{\frac{\mu_0 I a}{2\pi R} \ln \frac{s+a}{s}}$$

The current will flow **anticlockwise**.

$$\boxed{\Delta Q = \frac{\mu_0 I a}{2\pi R} \ln \frac{s+a}{s}}$$

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