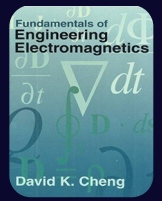
練習1

第4章，第157頁



Fundamentals of Engineering Electromagnetics

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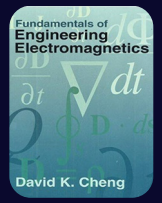
目錄

解答 已驗證 2年前提供

The main difference between convection and conduction currents is that conduction currents are governed by Ohm's Law, and convection currents are not. Both are caused by the motion of free charges.

練習2

第4章，第157頁



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解答 已驗證 2年前提供

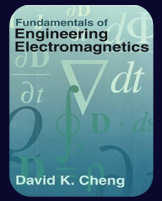
The relationship between convection current density $\vec{J}$ and the velocity of the charge carriers $\vec{u}$ is:

$$\vec{J} = \rho_e \vec{u},$$

where ρ_e is free charge per unit volume.

練習3

第4章，第157頁



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解答 已驗證 2年前提供

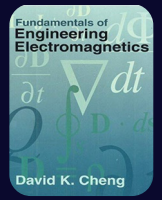
The mobility of the electron in a conductor μ_e, is a constant of proportionality between the average drift velocity and the electric field intensity:

$$\vec{u_e} = -\mu_e \vec{E}$$

It is measured in m^2/Vs.

練習4

第4章，第157頁



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解答 已驗證 2年前提供

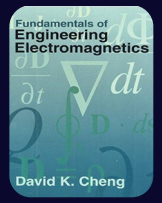
The point form of Ohm's Law is:

$$\vec{J} = \sigma \vec{E} \quad (\mathrm{A/m^2}),$$

where $\vec{J}$ is current density, σ is conductivity, and $\vec{E}$ is field intensity.

練習5

第4章，第157頁



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解答 已驗證 2年前提供

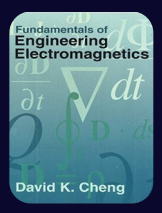
Conductivity σ is a macroscopic constitutive parameter of the medium, and it is reciprocal to resistivity. For semiconductors, it depends on the concentration and mobility of both electrons and holes:

$$\sigma = -\rho_e \mu_e + \rho_h \mu_h$$

The SI unit is $\frac{\mathrm{A}}{\mathrm{V \cdot m}}$ or $\frac{\mathrm{S}}{\mathrm{m}}$.

練習6

第4章，第157頁



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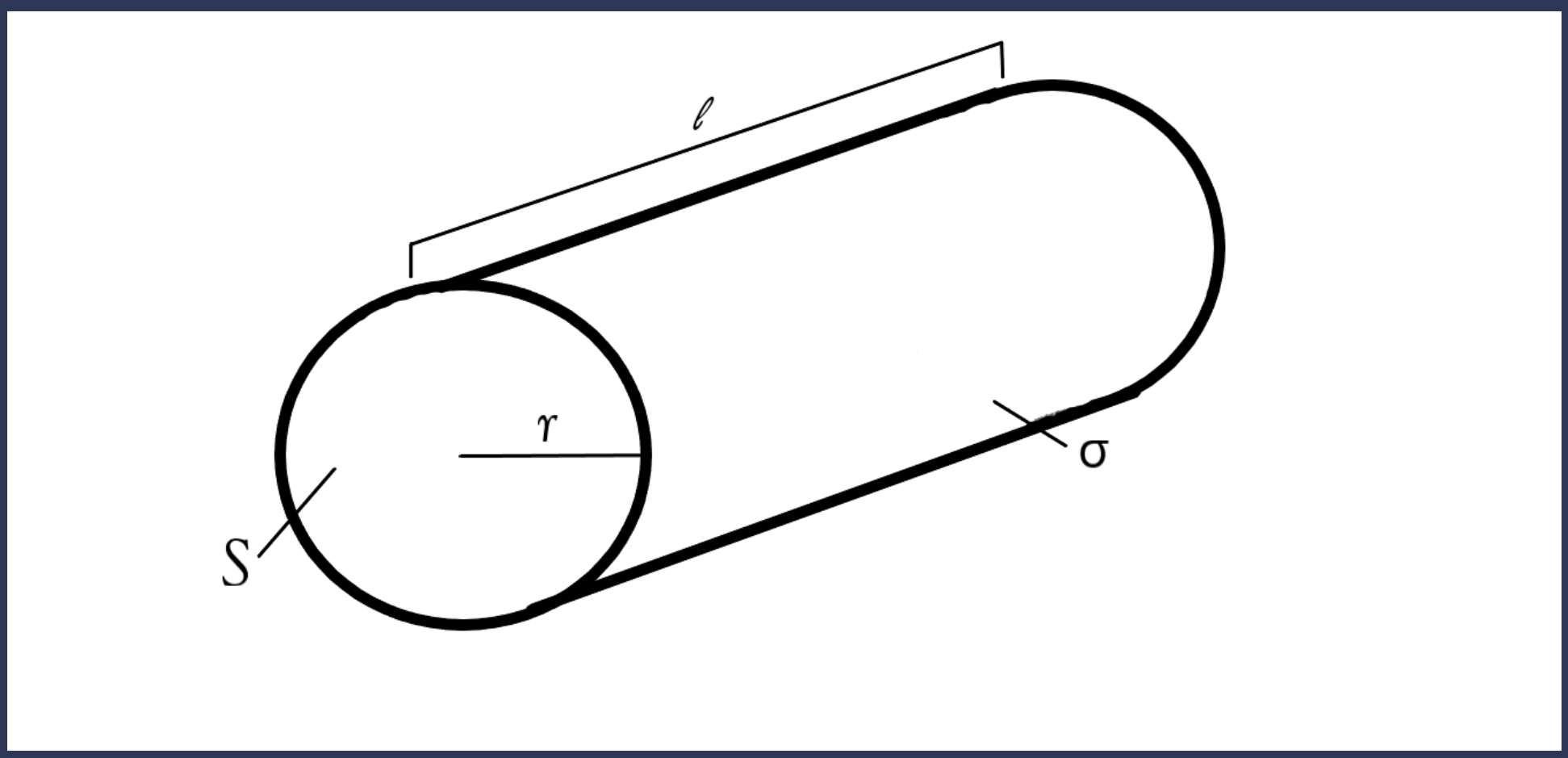
步驟1

步驟1 / 2

Resistance of a round wire is calculated using this formula:

$$R = \frac{l}{\sigma S}$$



步驟2

步驟2 / 2

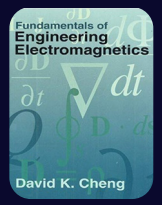
If the initial radius is r_1, then the doubled radius is $r_2 = 2 \cdot r_1$. Initial cross section of the wire is S_1, and now it is $S_2 = 4 \cdot S_1$, because $S = r^2\pi$. Now the resistance is:

$$R_2 = \frac{l}{\sigma S_2} = \frac{l}{\sigma \cdot 4S_1} = 0.25\frac{l}{\sigma S_1}$$

So, if the radius doubles, the resistance decreases 4 times.

練習7

第4章，第161頁



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解答 已驗證 2年前提供

The equation of continuity looks like this:

$$\Delta \cdot \vec{J} = -\frac{\partial \rho_v}{\partial t},$$

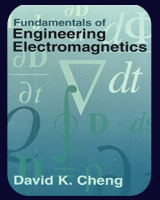
and, for steady currents it is reduced to this:

$$\Delta \cdot \vec{J} = 0$$

This means that steady currents are divergenceless, and the field lines close upon themselves.

練習8

第4章，第161頁



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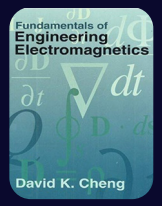
解答 已驗證 2年前提供

Kirchhoff's current law states that the algebraic sum of all the currents flowing out of a junction in an electric circuit is zero. It can be written as:

$$\sum_j I_j = 0$$

練習9

第4章，第161頁



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解答 已驗證 2年前提供

步驟1

步驟1 / 2

Relaxation time τ is a time constant, and it equals to:

$$\tau = \frac{\epsilon}{\sigma} \quad (\mathrm{s})$$

It is used for calculating how the volume density of the charge decays exponentially over time.

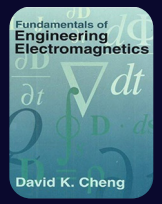
步驟2

步驟2 / 2

For copper, relaxation time is $\tau = 1.53 \times 10^{-19}$ s, so the order of magnitude is -19.

練習10

第4章，第161頁



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Joule's law states that for a volume V, the total electric power converted into heat is:

$$P = \int_V \vec{E} \cdot \vec{J}\, dv$$

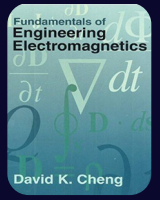
Using Ohm's Law $(\vec{J} = \sigma \vec{E})$, it can be written like this:

$$P = \int_V \vec{E} \cdot \vec{J}\, dv = \int_V \vec{E} \cdot \sigma \vec{E}\, dv = \int_V E \cdot \sigma\, dv$$

$$P = \int_V \vec{E} \cdot \vec{J}\, dv = \int_V \frac{\vec{J}}{\sigma} \cdot \vec{J}\, dv = \int_V \frac{J}{\sigma} \cdot dv$$

練習11

第4章，第161頁



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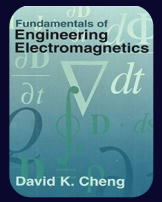
解答 已驗證 2年前提供

The boundary conditions of steady current at the interface of two media with different conductivities σ_1 and σ_2 are:

- normal components: $J_{1n} = J_{2n}$
- tangential components: $\dfrac{J_{1t}}{J_{2t}} = \dfrac{\sigma_1}{\sigma_2}$

練習12

第4章，第166頁



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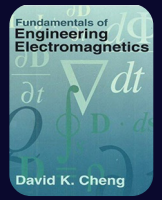
解答 已驗證 2年前提供

Relationship between conductance G and capacitance C can be described with this formula:

$$\frac{C}{G} = \frac{\epsilon}{\sigma}$$

練習13

第4章，第166頁



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解答 已驗證 2年前提供

Relationship between resistance R and capacitance C can be described with this formula:

$$RC = \frac{\epsilon_0 \epsilon_r}{\sigma}$$