ECE343 Spring 2025

Objective 6.1: Current Density



UNITED STATES AIR FORCE ACADEMY

Lesson	Topics	Reading	Notes
24	BVP (Capacitor, Coax), Electric Potential	5.16	LO 5.3
25	Electric Boundary Conditions	5.18-5.22	LO 5.4
26	BC's/Capacitance	5.23-5.24	
27	Electrostatic Lab	Lab packet	
Chapter 6: Steady Current & Conductivity			
28	Current density, Conductivity, Resistance	Ch. 6	
Chapter 7: Magnetostatics			
29	Magnetic Fields, Gauss' Law for Magnetism	7.1-7.3	LO 7.1-7.2 **GR 2**
30	Ampere's Law	7.4-7.5, 7.9	LO 7.3
31	Ampere's Law Applied	7.6-7.8	LO 7.3
32	Magnetic Boundary Conditions	7.10-7.14	LO 7.4
33	Magnetostatics Lab	Lab packet	
Chapter 8: Time-Varying Fields			
34	Faraday's Law, Displacement Current, Maxwell Eqns	8.3, 8.8, 8.9	LO 8.1
35	Faraday's Law, Displacement Current, Maxwell Eqns	8.3, 8.8, 8.9	LO 8.2-8.3
Chapter 9: Plane Waves in Lossless Media			
36	Maxwell's Equations in lossless, source-free region	9.1-9.2	LO 9.1
37	Maxwell's Equations in lossless, source-free region	9.1-9.2	LO 9.1
38	Uniform Plane Waves & Polarization	9.4-9.6	LO 9.2-9.3
39	Normal Incidence	Vol 2, 5.6-5.7	LO 9.4-9.5
40	Oblique Incidence	Vol 2, 5.6-5.7	LO 9.5
41	Oblique Incidence	Vol 2, 5.6-5.7	LO 9.5
42	Incidence Lab	TBD	LO 9.5

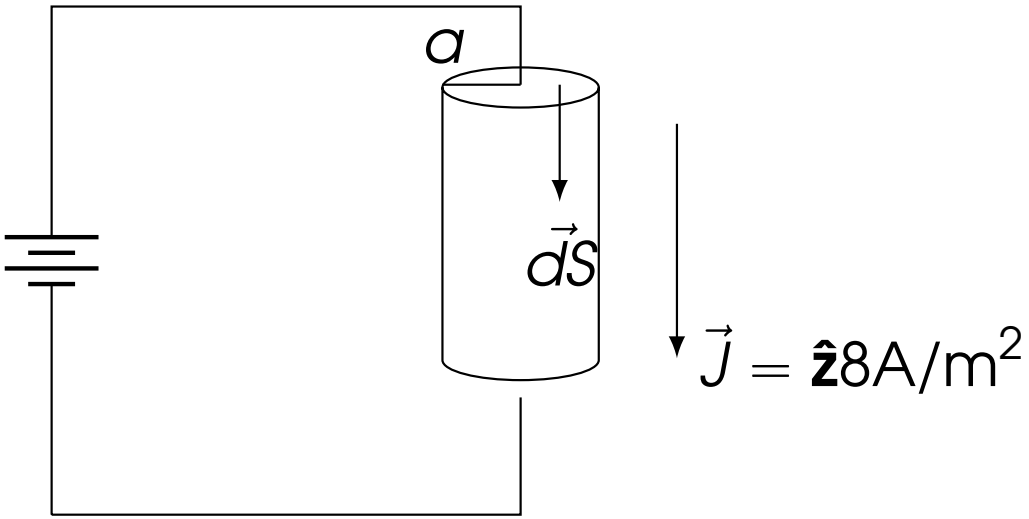
Ch 6 Learning Objectives

5.1 I can calculate the total current through a surface area given a current distribution.

5.2 I can use Ohm's Law for electromagnetics to calculate the relationship between a current distribution and an electric field.

5.3 I can articulate and identify what makes a material a good conductor and how conductivity relates to resistance.

Current Distributions



Conductivity

Definition

$$\vec{J} = \sigma \vec{E}$$

$$\Longrightarrow \quad \sigma \longrightarrow \frac{1}{\Omega} = \text{S (Siemens)}$$

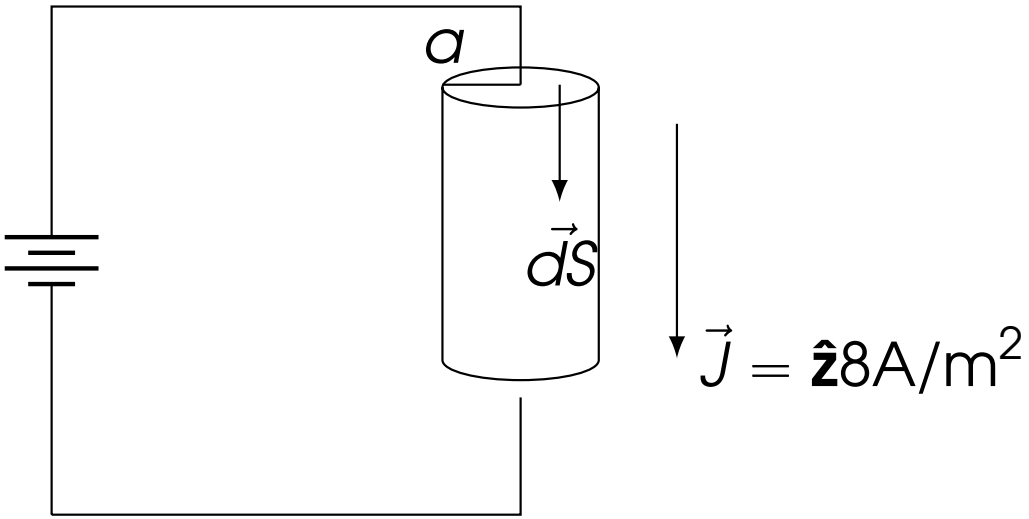
Types of Conductors

1. "Good" conductor $\longrightarrow \sigma > 10^5$ S/m
2. Semiconductor $\longrightarrow \times 10^{-4} < \sigma < 10$ S/m
3. Poor insulators $\longrightarrow 10$ S/m
4. Good insulators $\longrightarrow \sigma < \times 10^{-10}$ S/m
5. Vacuum $\longrightarrow 0$

Conductivity for Common Materials

Material	σ (S/m)
Copper	5.8×10^7
Gold	4.4×10^7
Aluminum	3.7×10^7
Iron	1.0×10^7
Platinum	0.9×10^7
Carbon	1.3×10^5
Silicon	4.4×10^{-4}
Free space	≈ 0
Distilled water	6×10^{-6}
Tap water	$5 - 50 \times 10^{-3}$
Seawater	5
Soil	1×10^{-4}

Resistance of a Wire



Resistance of a Coaxial Cable

Find the resistance between the inner and outer conductor of a coaxial cable of length (in z-dimension) ℓ.

