Lecture 12: Dielectrics and the Equation of Continuity

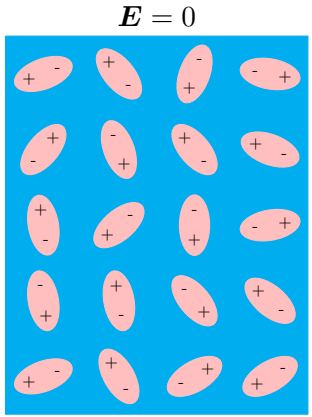
ECE221: Electric and Magnetic Fields

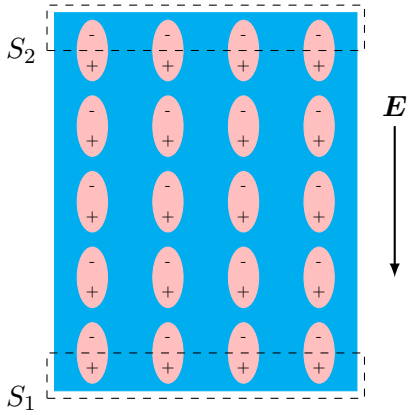
Prof. Sean V. Hum

Winter 2019

Outline

Polarization of a Dielectric





Dielectric Breakdown

The **dielectric strength** is the maximum electric field that a dielectric can withstand without electrical breakdown.

Table of Dielectrics

Material	Dielectric constant ϵ_r	Dielectric strength ($\times 10^6$ V/m)
Vacuum	1	∞
Dry air (1 atm)	1.00059	3.0
Teflon^{TM}	2.1	60 to 173
Paraffin	2.3	11
Silicon oil	2.5	10 to 15
Polystyrene	2.56	19.7
Nylon	3.4	14
Paper	3.7	16
Fused quartz	3.78	8
Glass	4 to 6	9.8 to 13.8
Concrete	4.5	–
Diamond	5.5	2,000
Mica	6.0	118
Water	80	–
Titanium dioxide	86 to 173	–
Strontium titanate	310	8
Barium titanate	1,200 to 10,000	–
Calcium copper titanate	$>$ 250,000	–

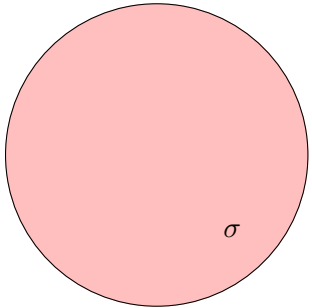
Conservation of Charge and the Equation of Continuity

Charges cannot be created or destroyed.

What is the circuit equivalent of this law?

Relaxation Time

Consider a problem where charges are introduced into the interior of a conductor during the time $t < 0$. What happens for $t > 0$?



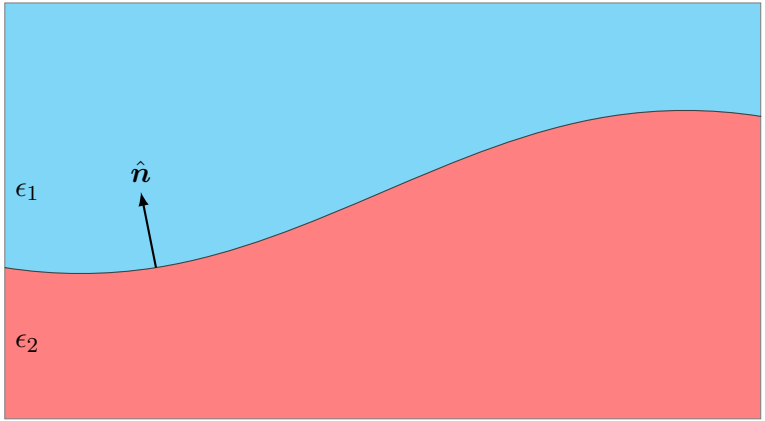
Relaxation Time

Relaxation time is the time it takes a charge density placed in the interior of a material to drop to $e^{-1} = 36.8\%$ of its original value.

Boundary Conditions: Dielectric-Dielectric Interface

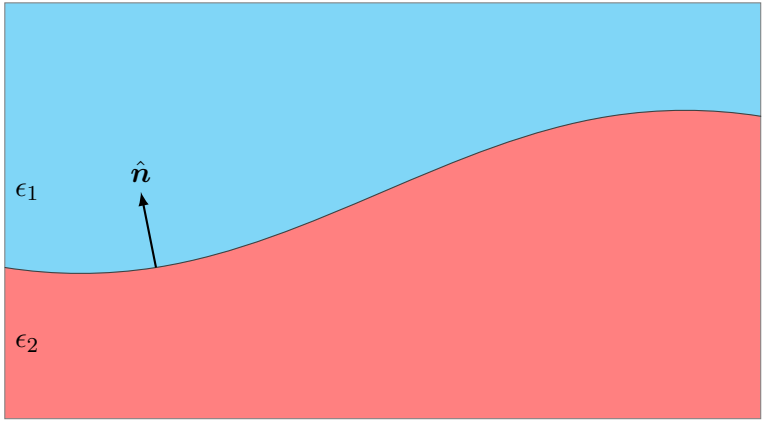
Consider an interface between two dielectric materials, and apply

$$\oint_C \boldsymbol{E} \cdot d\boldsymbol{\ell} = 0$$



Boundary Conditions: Dielectric-Dielectric Interface

Consider an interface between two dielectric materials, and apply **Gauss' Law**.



Boundary Conditions: Dielectric-Conductor Interface