ECE343 Spring 2025

Objective 12: Concepts Review and Fields



UNITED STATES
AIR FORCE
ACADEMY

Lesson	Topics	Reading	Notes
1	Course Overview & Introduction	Ch.1	LO 1.1-1.2
Chapter 2: Electric and Magnetic Fields			
2	Fields, Parameters, Field Quantities	Ch. 2	LO 2.1-2.2
Chapter 3: Transmission Lines			
3	Lumped Element Model	3.1-3.4	LO 3.1
4	Telegrapher's Equations	3.5-3.6	LO 3.1
5	Characteristic Impedance & Wave Propagation	3.7-3.9	LO 3.2
6	Coaxial, Reflection Coefficient, VSWR	3.10,3.12-3.14	LO 3.2-3.3
7	Terminated Transmission Lines	3.15,3.17-3.19	LO 3.4
8	Impedance Matching	3.21-3.23	LO 3.4
9	Impedance Matching	3.21-3.23	LO 3.4
10	Smith Charts	Supplemental	LO 3.5
11	Smith Charts	Supplemental	LO 3.5
12	Smith Charts	Supplemental	LO 3.5
13	Smith Charts	Supplemental	LO 3.5
14	Transients	Supplemental	LO 3.6
15	Reflection/Transmission Coefficient Lab	Lab Packet	LO 3.7
Chapter 4: Vector Analysis			
16	Vector & Coordinate System Review	Ch. 4	LO 4.1-4.4 **GR 1 due**
Chapter 5: Electrostatics			
17	Coulomb's Law	5.1-5.3	LO 5.1
18	Surface and Volume Charge	5.4	LO 5.1
19	Gauss' Law (Integral Form)	5.5-5.6	LO 5.2
20	Gauss' Law (Differential Form)	5.7-5.8	LO 5.2
21	Electric Potential	5.9-5.10, 5.15	LO 5.3

Ch 2 Learning Objectives

2.1 I can recall the definition of scalar fields, vector fields, phasors, and Euler's identity.

2.2 I can explain the basic terms and quantities used to describe electromagnetic fields.

What is a field?

Field - Definition

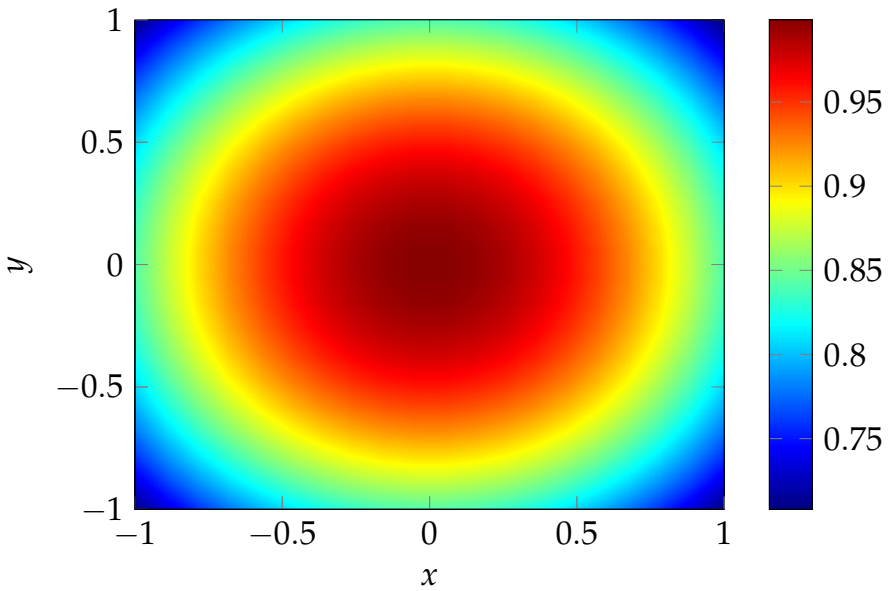
A field is the continuum of values of a quantity as a function of position and time.

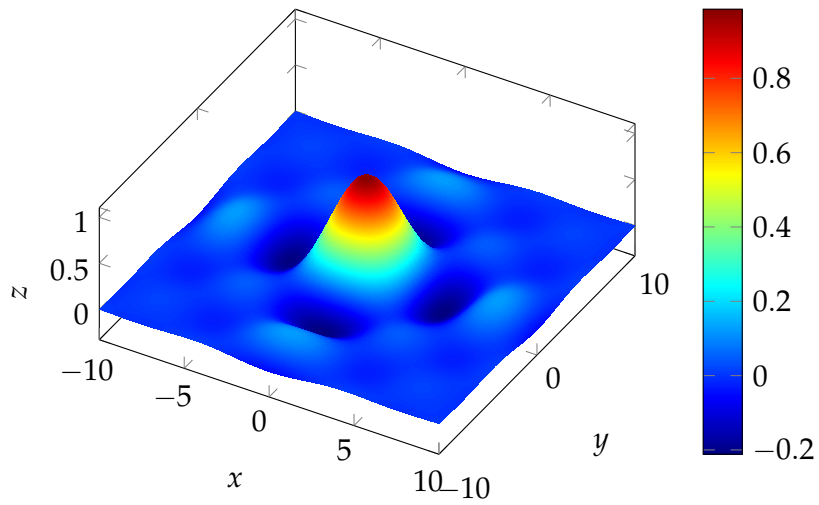
Fields can be Scalar or Vector

Scalar Examples

Vector Examples

Field Representation

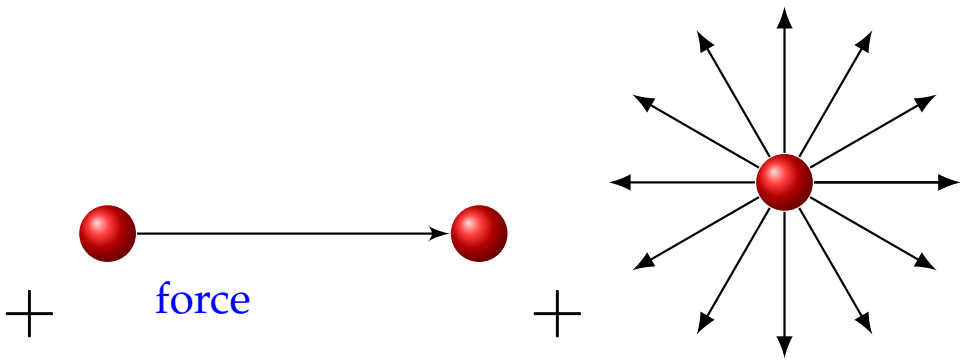




Electric Field

Basics

- **Electric Field Intensity** is a vector field that quantifies the force experienced by a charged particle due to the influence of a charge not associated with that particle.
- **Units** $\longrightarrow$ N/C $\longrightarrow$ V/m
- **Direction** $\longrightarrow$ points in the direction in which electric potential is most rapidly decreasing.



Electromagnetic Material Properties

Permittivity, ε

Quantifies the effect of an electric field on a material.

Permeability, μ

Quantifies the effect of current in producing a magnetic flux density within a material.

Conductivity, σ

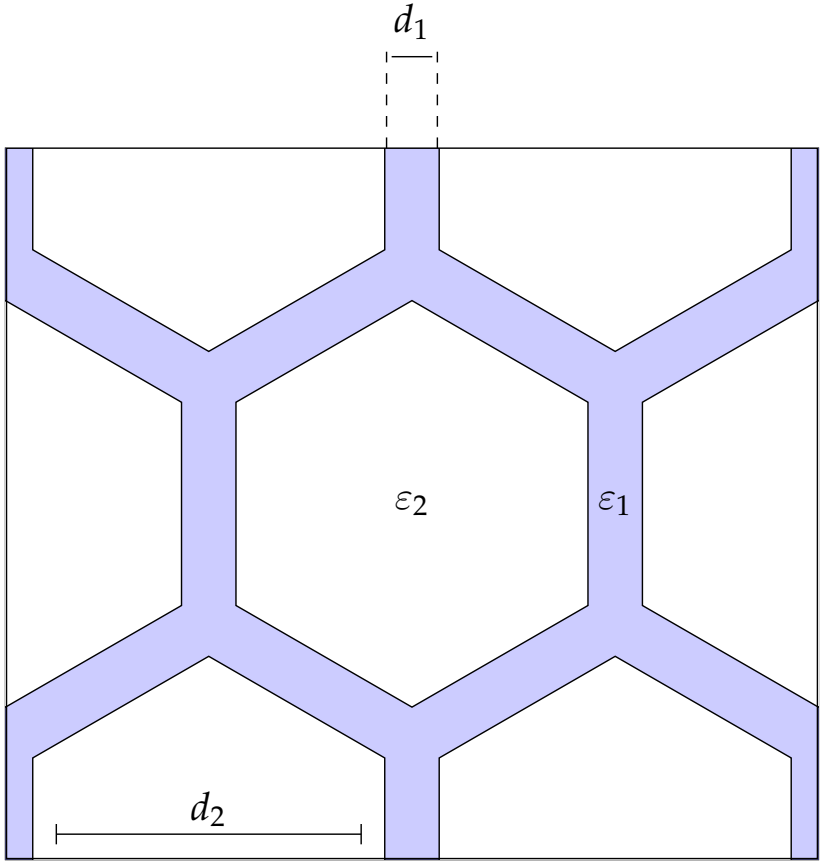
Quantifies the effect of current flow in response to an applied electric field.

PERMITTIVITY

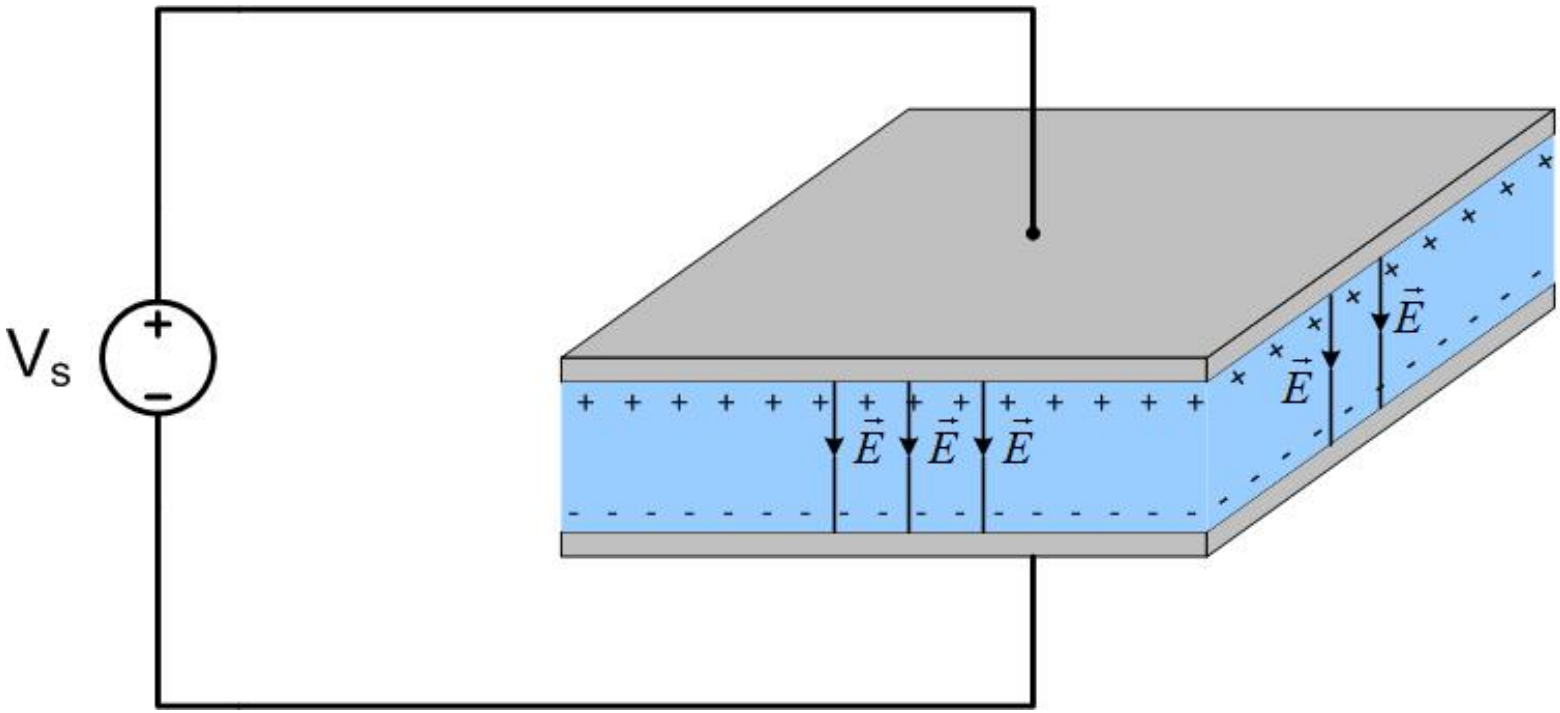
- Definition $\longrightarrow$ the effect of material in determining the electric field in response to electric charge.

- Physical Interpretation $\longrightarrow \vec{E} = \hat{r}\frac{q}{4\pi\varepsilon|r|^2}$

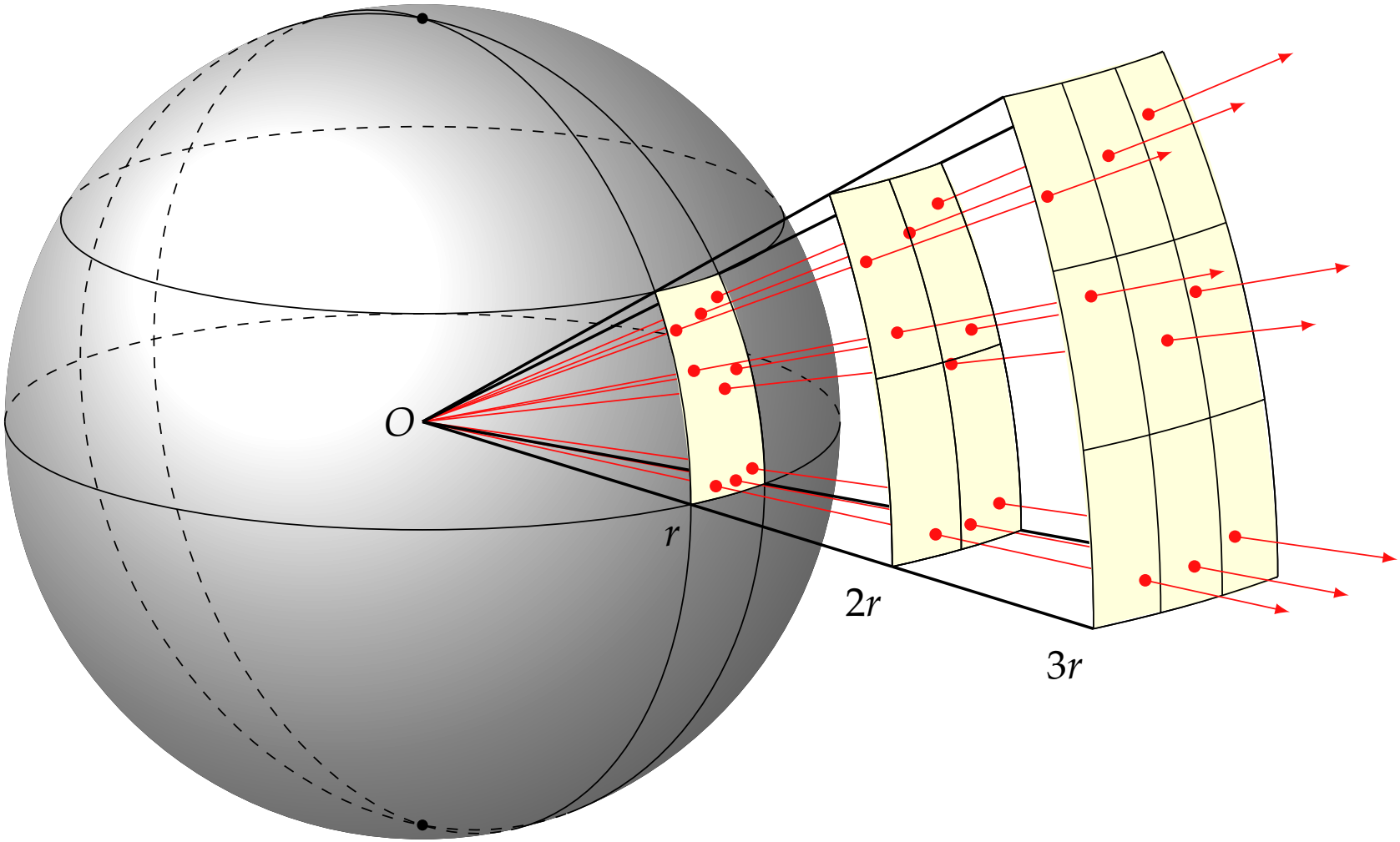
- Units $\longrightarrow$ F/m



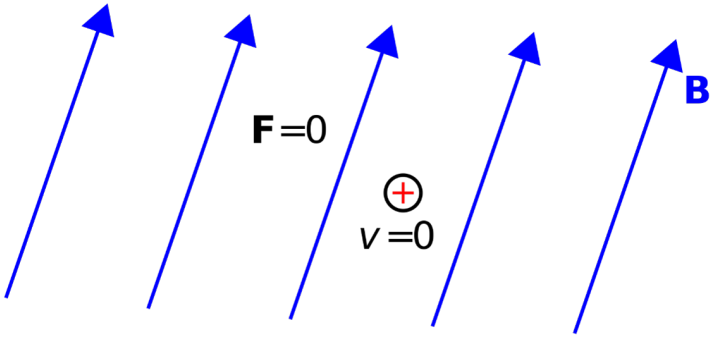
Parallel Plate Capacitor

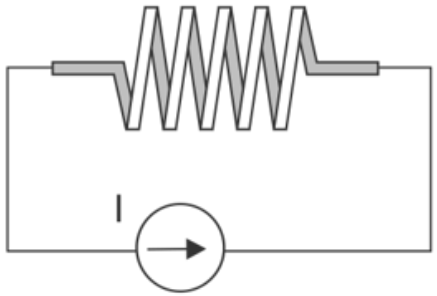


Electric Flux Density

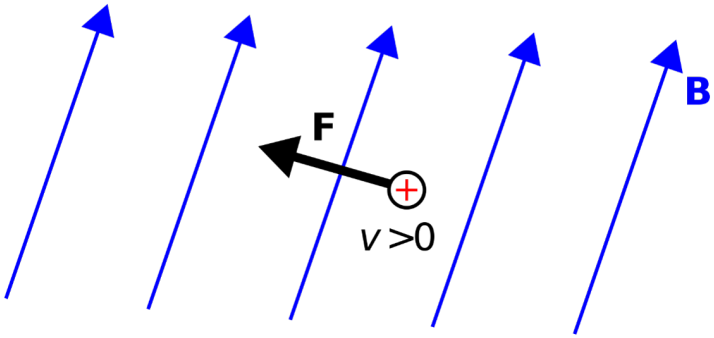


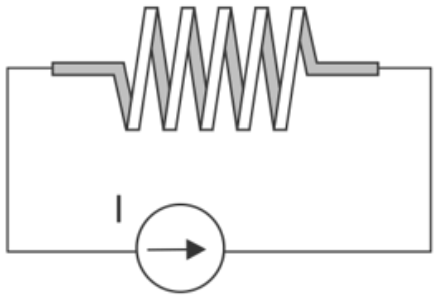
Magnetic Fields







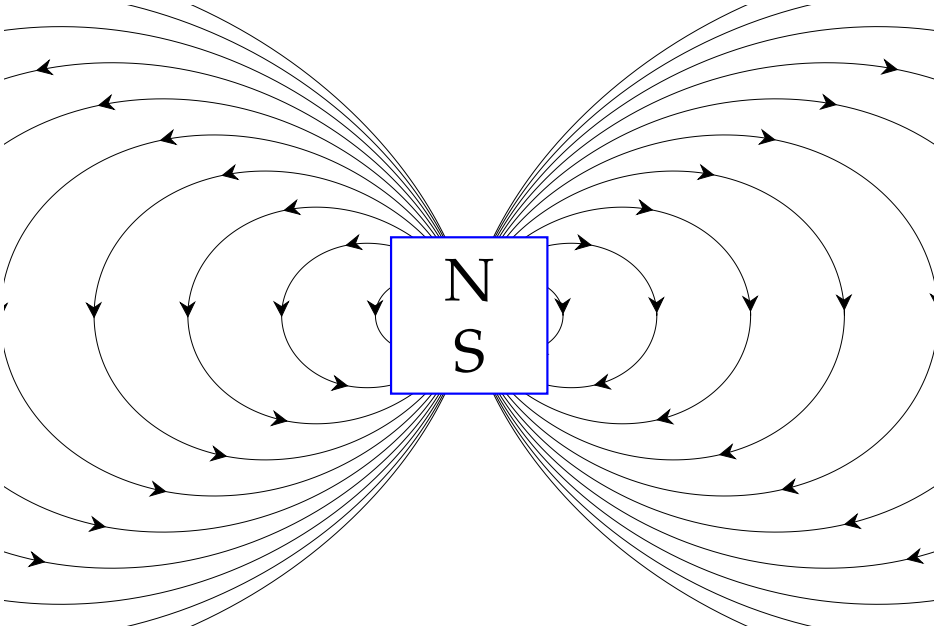






$$\vec{F} =$$

Magnetic Fields, Permeability, Magnetic Flux Density



$$\vec{B}(r) = \mu \frac{qv}{4\pi R^2} \times \hat{R}$$

$$\vec{B} = \mu \vec{H}$$

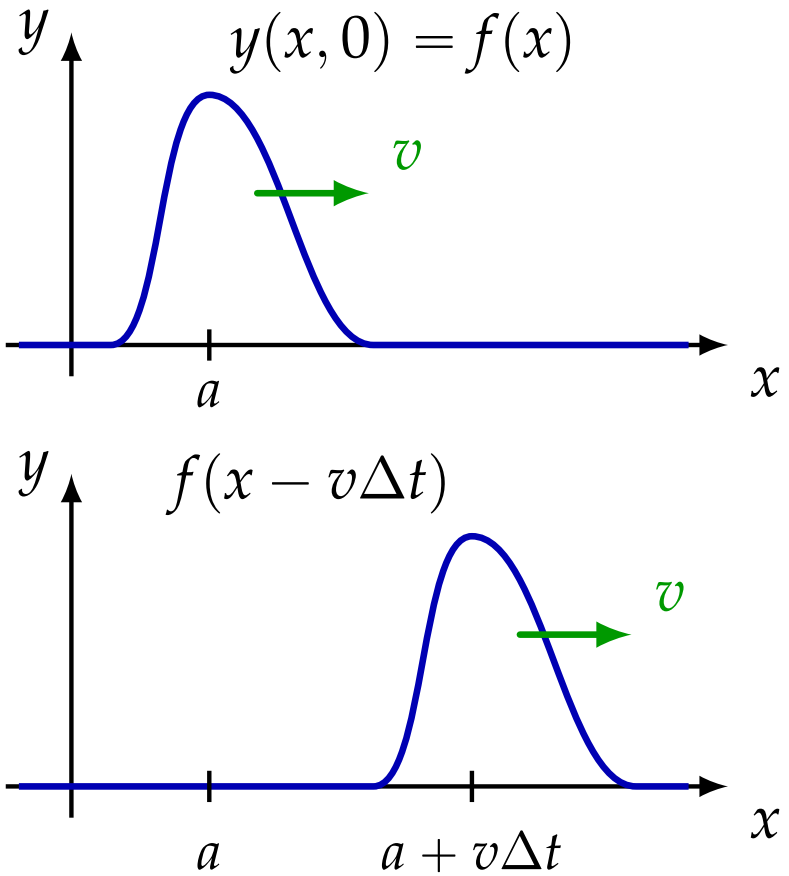
Electromagnetic Material Categories

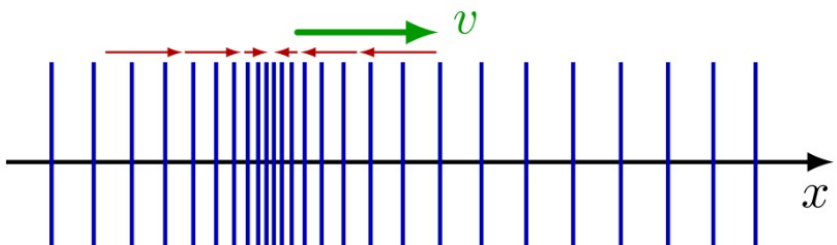
- **Homogeneous:** Material is the same, regardless of position of applied field.
- **Isotroipc:** Material response is independent of orientation to the applied field.
- **Linear:** Linear response to applied fields.
- **Non-dispersive:** Material response is independent of frequency of applied field.

Waves

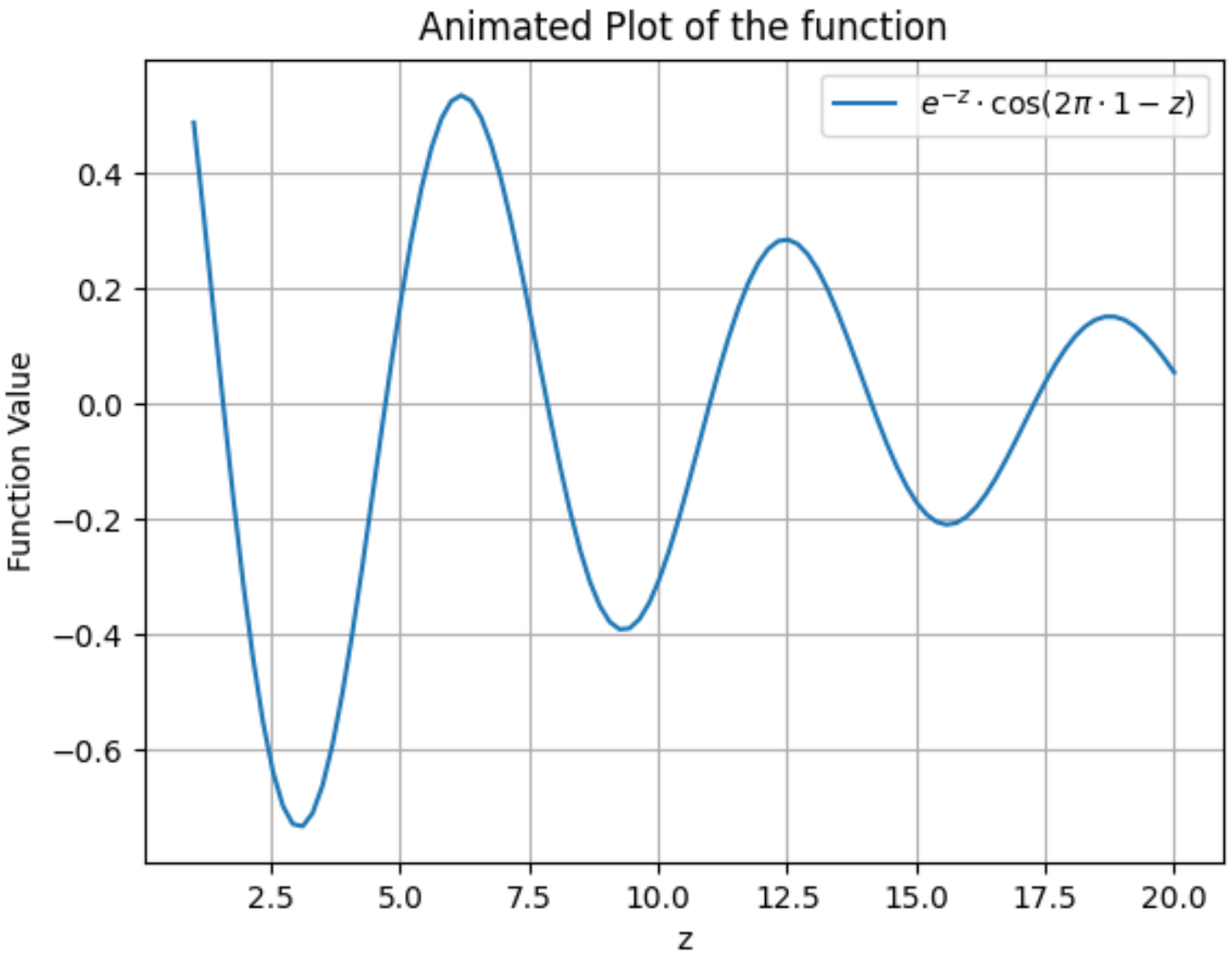
Wave - Definition

A wave is a time-varying field that continues to exist in the absence of the source that created it and is therefore able to transport energy.





Wave Animation



Remember Euler?

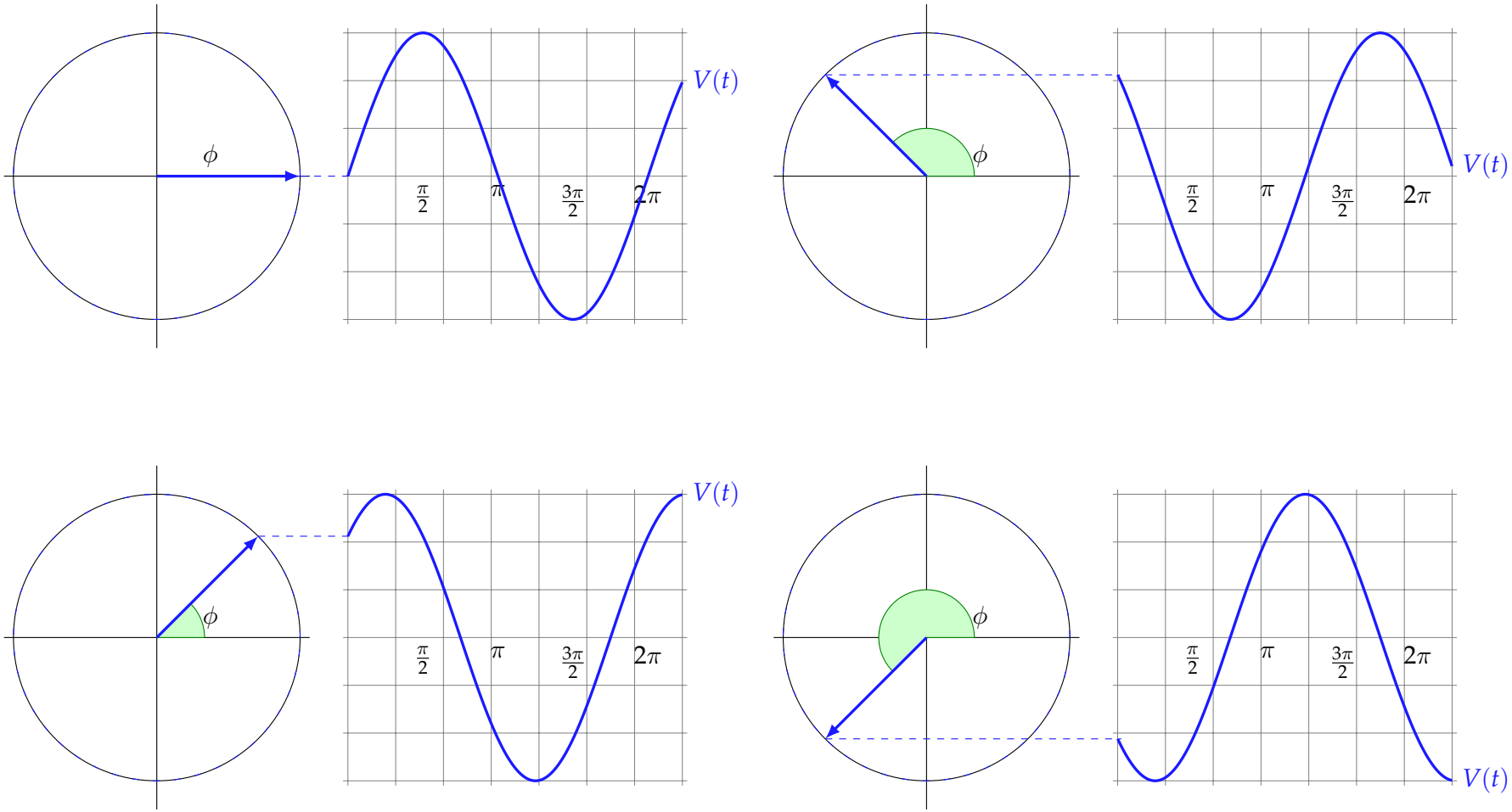
$$e^{j\theta} = \cos(\theta) + j\sin(\theta)$$

$$e^{-j\theta} = \cos(\theta) - j\sin(\theta)$$

$$\cos(\omega t) = \frac{e^{j\omega t} + e^{-j\omega t}}{2}$$

$$\sin(\omega t) = \frac{e^{j\omega t} - e^{-j\omega t}}{j2}$$

PHASORS


ϕ
$V(t)$
$\frac{\pi}{2}$
π
$\frac{3\pi}{2}$
2π
ϕ
$V(t)$
$\frac{\pi}{2}$
π
$\frac{3\pi}{2}$
2π
ϕ
$V(t)$
$\frac{\pi}{2}$
π
$\frac{3\pi}{2}$
2π
ϕ
$\frac{\pi}{2}$
π
$\frac{3\pi}{2}$
2π
$V(t)$