EEE108 Engineering Electromagnetism and Drives

Lecture 1

Introduction

Dr. Jinling Zhang

Dept. of Electrical and Electronic Engineering
University of Xi'an Jiaotong-Liverpool
Email: jinling.zhang@xjtlu.edu.cn

Derek Gray

EE524

labs: EE424 & EE413

derek.gray@xjtlu.edu.cn

…I'm normally in my office or labs…

but making an appointment is safest

Tutorials, Test, and Exam

Assessment (*5 Credits, 150 hours*)

– Midterm exam 15% (Week 7)

– Laboratory 15% (2 Lab Sessions)

No Resit !!

– Final examination / Resit 70% (3 hours)

Submission:

- Lab reports: Soft copy (to ICE)

Late Submission: University policies apply

Resit: University policies apply – pass/fail only

Module Syllabus

Electromagnetism

- Introduction to simple electrostatics
- Electrical Current
- Maxwell's Equations:
  - Gauss's Law
  - Ampere's Law
  - Gauss's law for magnetism
  - Faraday's Law

Drives

- Electromagnetic induction
- Moving coil transducers
- Linear actuators
- DC rotating machines
- AC rotating machines
- Transformer

Interactive Learning Process

Reference Books:

note that books are NOT compulsory

had special edition combining the 2 textbooks

❖ Electromagnetism And Electromechanics, McGraw-Hill Education

Engineering Electromagnetics + Electric Machinery Fundamentals

...maybe can obtain this 2nd hand

individually:

- Engineering Electromagnetics, Hayt & Buck, 8th edition, McGraw Hill
- Electric Machinery Fundamentals, Chapman, 5th edition, McGraw Hill

others:

- Electromagnetics for Engineers: with Applications to Digital Systems and Electromagnetic Interference, C. P. Paul, Wiley
- Electrical Machinery, Fitzgerald, A.E., Kingsley, C. and Umans, S.D., 6th Ed. McGraw-Hill

Interactive Learning Process

Lecture, Tutorial Notes: ICE

Print them out before the lectures

They may be not be complete, such as no solutions for the end of lecture questions, …

Rewrite and summarise lecture notes and textbook

Do end of chapter problems

Lab/Practices: 2 lab sessions

Study alone

Study together

…if after some attempts, you can't figure something out…

…ASK!

Timetable and Outline

- Lectures + Tutorials

  14:00 to 16:00, Monday, EE101

  14:00 to 16:00, Friday, EE101

- Lab 1: Plotting potential & field lines
- Lab 2: Transformers

Lab arrangements

EEE Lab List - (2016-2017 Semester2)				
Week	Day	# students	Room	Time
3	Tuesday	180	205/211	11:00 – 13:00 14:00 – 18:00
4	Tuesday	180	205/211	11:00 – 13:00 14:00 – 18:00
10	Tuesday	180	313/315	11:00 – 13:00 14:00 – 18:00
11	Tuesday	180	313/315	11:00 – 13:00 14:00 – 18:00

lab day & lab group will be posted on ICE

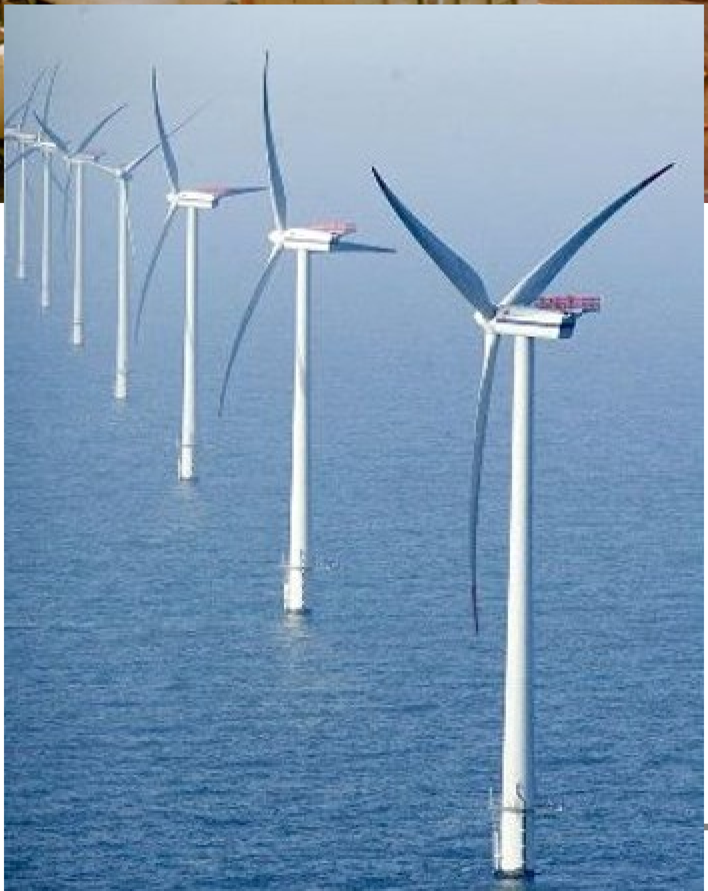
Why Study Electromagnetics?

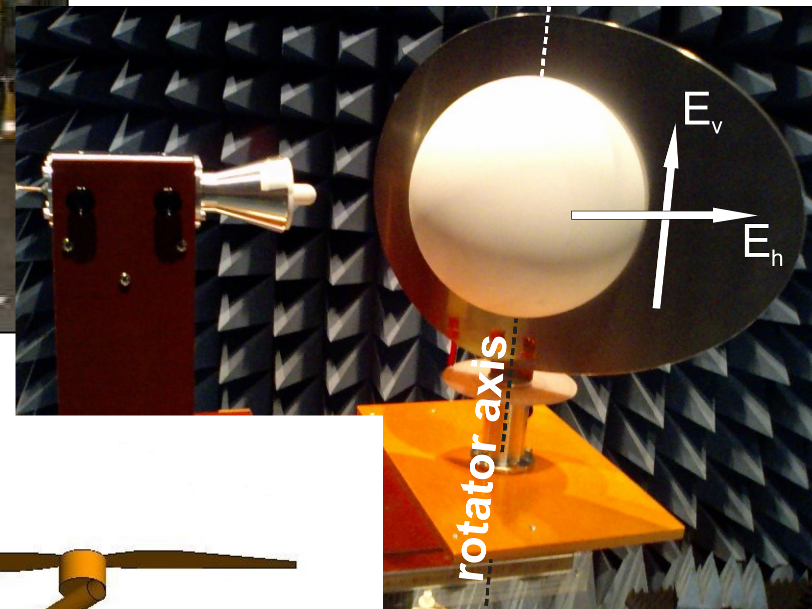
Electromagnetics is everywhere!

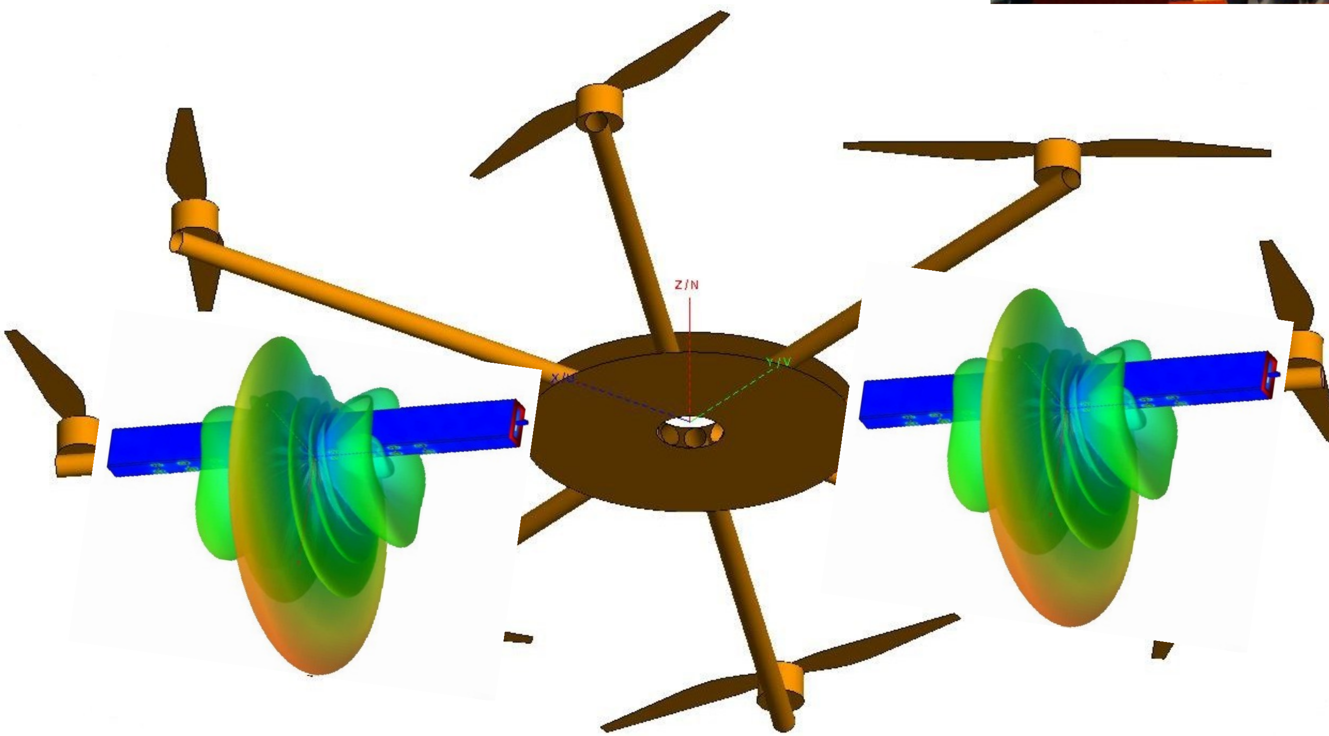
Electromagnetic (EM) is one of the fundamental forces.

EM principles and laws govern all electrical and computer engineering systems.

…& fundamental to motors & generators…




E_v
E_h
rotator axis


Z/N
Y/V

Basic principals

Electric and Magnetic Fields are:

- three dimensional
- vector
- modeled by partial differential equations
- vary in space and as well as time

Today's Lecture

Review of Vector Calculus

The EM quantities, such as electrical field intensity, electric flux density, magnetic field intensity, and magnetic flux density, are vector quantities.

Scalars

A **scalar** is a quantity which has magnitude (numerical size) only.

Requires 2 things:

1. A value
2. Appropriate units

examples: Mass: 5 kg

Temp: 21^{o}C

Distance: 65 km

Scalars

A **scalar** is a quantity which has magnitude (numerical size) only.

Requires 2 things:

1. A value
2. Appropriate units

getting the right answer is good…

Mass: 5 kg

Temp: 21^{o}C

Distance: 65 km

Scalars

A **scalar** is a quantity which has magnitude (numerical size) only.

Requires 2 things:

1. A value
2. Appropriate units

getting the right answer is good…

but having the units correct proves to me that you understand what is going on!

Mass: 5 kg

Temp: 21^{o}C

Distance: 65 km

Vectors

1. What are vectors?
2. Vector notation
3. Vector representation
4. Vector operations

Definition of vectors?

A **vector** is a quantity which has both a magnitude and a direction.

Requires 3 things:

1. A value
2. Appropriate units
3. **A direction!**

examples: Acceleration: 9.8 m/s^2 down

Velocity: 25 km/h West

Definition of vectors?

A **vector** is a quantity which has both a magnitude and a direction.

getting the right answer is good…

Requires 3 things:

1. A value
2. Appropriate units
3. **A direction!**

examples: Acceleration: 9.8 m/s^2 down

Velocity: 25 km/h West

Definition of vectors?

A **vector** is a quantity which has both a magnitude and a direction.

Requires 3 things:

1. A value
2. Appropriate units
3. **A direction!**

getting the right answer is good…

but having the units correct proves to me that you understand what is going on!

examples: Acceleration: 9.8 m/s^2 down

Velocity: 25 km/h West

Vector Notation

A widely used convention is to denote a vector quantity in bold type, such as **A**.

You may also encounter the notation: $\overset{\rho}{A}$, $\hat{A}$ or $\overset{\omega}{A}$

The magnitude of a vector **A** is written as |**A**| or A/*A*.

here for EEE108:

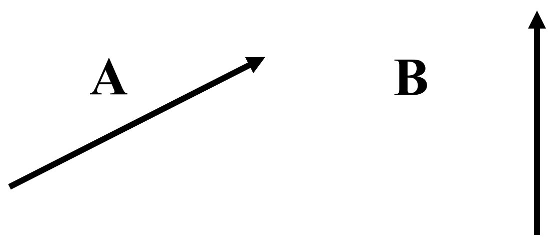
Typing: boldface typing, such as **A**

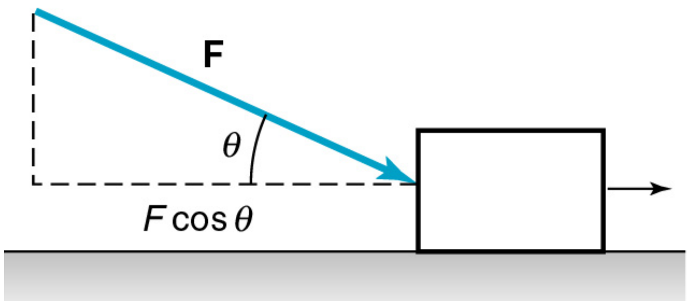
Handwriting: use a right-pointing arrow above the vector: $\vec{A}$

Vector Representation

We represent vectors graphically or quantitatively:

Graphically: through arrows with the orientation representing the direction and length representing the magnitude





Quantitatively:

Represent a vector $\mathbf{A}$ quantitatively by the magnitude and the direction :

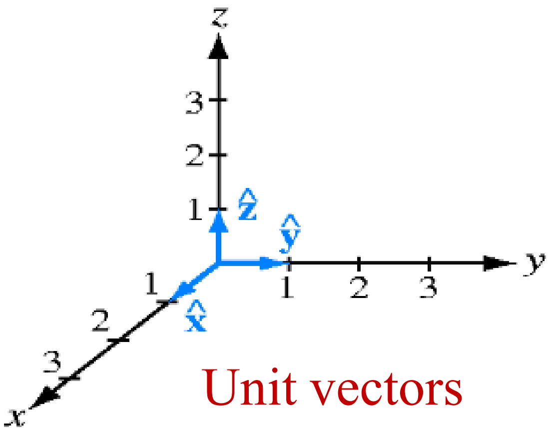
$$\mathbf{A} = \mathbf{a}\left|\mathbf{A}\right| = \mathbf{a}A \quad \text{where } \mathbf{a} = \frac{\mathbf{A}}{\left|\mathbf{A}\right|} = \frac{\mathbf{A}}{A}$$

$\mathbf{a}$: called unit vector

Vector Representation

A right-hand coordinate system having orthogonal axes is usually chosen:

- Cartesian,
- circular cylindrical
- spherical



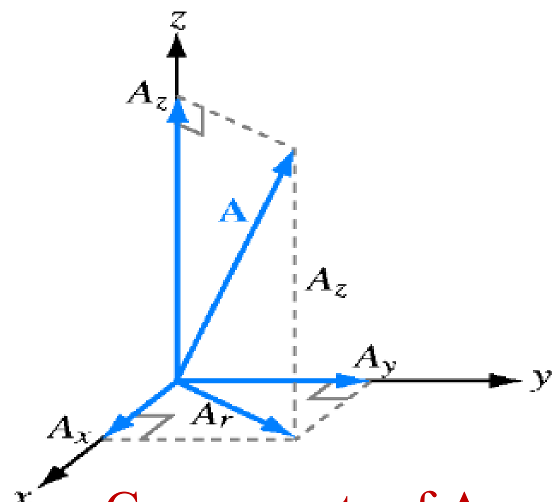
Unit vectors

In Cartesian coordinates :

$$\mathbf{A} = A_x \mathbf{a}_x + A_y \mathbf{a}_y + A_z \mathbf{a}_z$$

$$A = \sqrt{A_x^2 + A_y^2 + A_z^2}$$

Unit vector : $\hat{\mathbf{x}}, \hat{\mathbf{y}}, \hat{\mathbf{z}}$ or $\hat{\mathbf{i}}, \hat{\mathbf{j}}, \hat{\mathbf{k}}$



Components of **A**

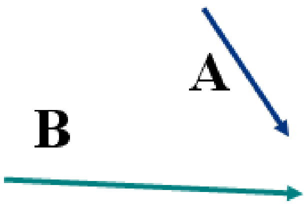
Vector Operations

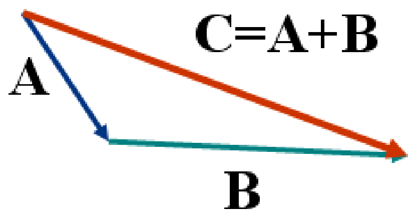
- Vector Addition

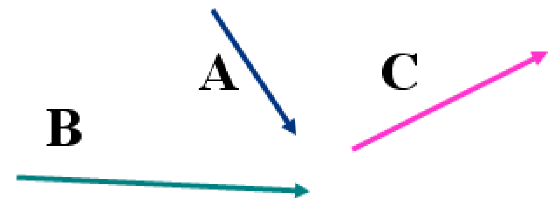
- Vector Subtraction

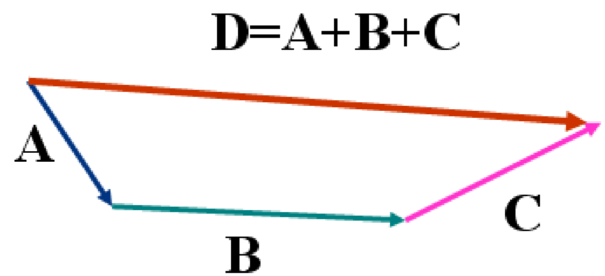
- Vector Multiplications:
  - Scalar or Dot Product
  - Vector or Cross Product

Vector Addition and Subtraction

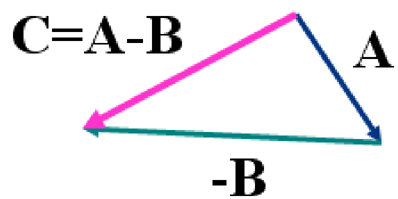








$C=A-B=A+(-B)$



$A=C-B=C+(-B)$

$B=C-A=C+(-A)$

$$D=A+B+C$$
$$=(A+B)+C$$
$$=A+(B+C)$$

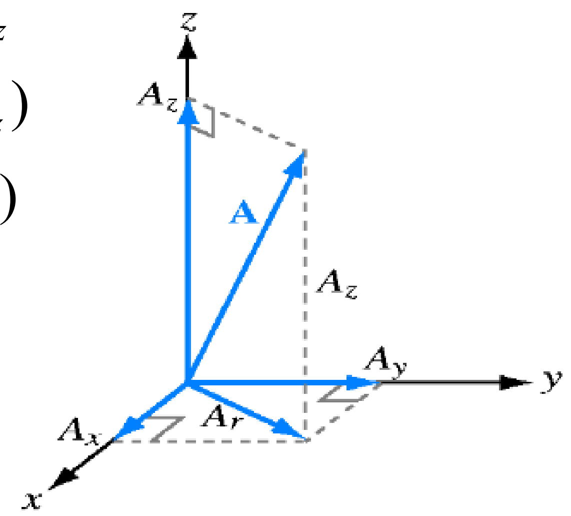
Vector Addition and Subtraction

In Cartesian coordinates :

$$\mathbf{A} = A_x\mathbf{a}_x + A_y\mathbf{a}_y + A_z\mathbf{a}_z \qquad \mathbf{B} = B_x\mathbf{a}_x + B_y\mathbf{a}_y + B_z\mathbf{a}_z$$

Then $\mathbf{A}+\mathbf{B} = \mathbf{a}_x(A_x + B_x) + \mathbf{a}_y(A_y + B_y) + \mathbf{a}_z(A_z + B_z)$

and $\mathbf{A}-\mathbf{B} = \mathbf{a}_x(A_x - B_x) + \mathbf{a}_y(A_y - B_y) + \mathbf{a}_z(A_z - B_z)$



Similarly…

$$\mathbf{A}+\mathbf{B}+\mathbf{C} = \mathbf{a}_x(A_x + B_x + C_x) + \mathbf{a}_y(A_y + B_y + C_y) + \mathbf{a}_z(A_z + B_z + C_z)$$

$$\mathbf{A}-\mathbf{B}-\mathbf{C} = \mathbf{a}_x(A_x - B_x - C_x) + \mathbf{a}_y(A_y - B_y - C_y) + \mathbf{a}_z(A_z - B_z - C_z)$$

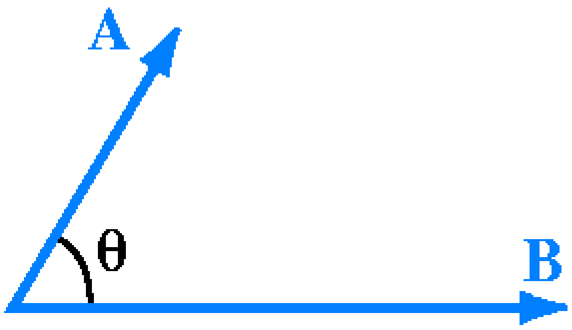
Scalar or Dot Product

$$\mathbf{A} \bullet \mathbf{B} = AB\cos\theta \quad \leftarrow \text{a scalar number}$$

$$\mathbf{A} \bullet \mathbf{B} = \mathbf{B} \bullet \mathbf{A}$$

$$\mathbf{A} \bullet \mathbf{A} = A * A\cos 0^{\circ} = A^2$$

$$\mathbf{A} \bullet (\mathbf{B} + \mathbf{C}) = \mathbf{A} \bullet \mathbf{B} + \mathbf{A} \bullet \mathbf{C}$$



In Cartesian coordinates:

$$\mathbf{A} = A_x\mathbf{a}_x + A_y\mathbf{a}_y + A_z\mathbf{a}_z \qquad \mathbf{B} = B_x\mathbf{a}_x + B_y\mathbf{a}_y + B_z\mathbf{a}_z$$

Then $\mathbf{A} \bullet \mathbf{B} = A_xB_x + A_yB_y + A_zB_z$

Vector or Cross Product

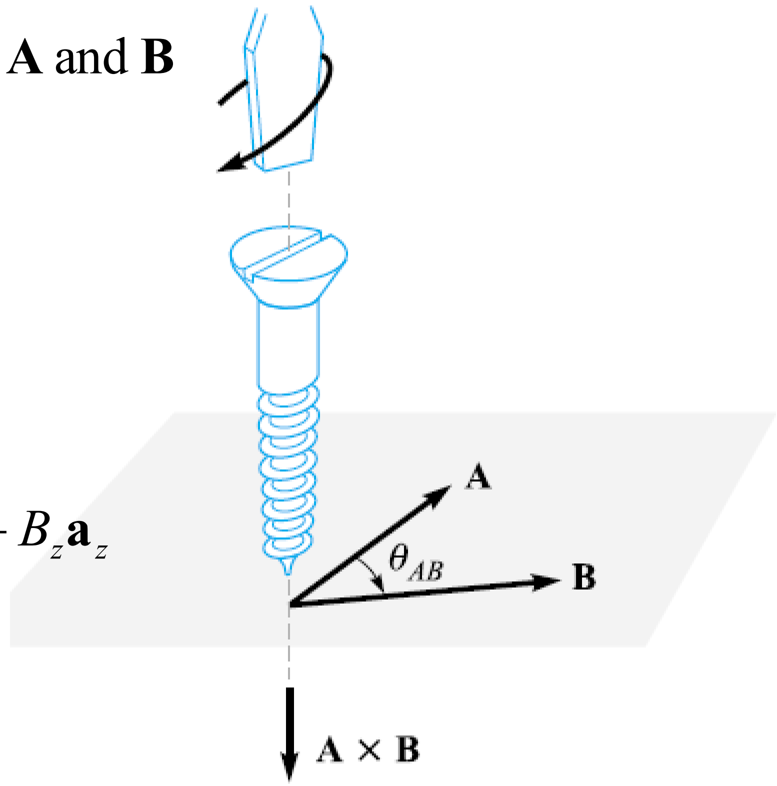
$\mathbf{A}\times\mathbf{B}=\mathbf{a}_n AB\sin\theta \quad \leftarrow$ a vector

$\mathbf{a}_n$ is a unit vector normal to the plane containing $\mathbf{A}$ and $\mathbf{B}$

$\mathbf{A}\times\mathbf{B}\neq\mathbf{B}\times\mathbf{A}$

$\mathbf{A}\times\mathbf{A}=0$

$\mathbf{A}\times(\mathbf{B}+\mathbf{C})=\mathbf{A}\times\mathbf{B}+\mathbf{A}\times\mathbf{C}$



In Cartesian coordinates:

$\mathbf{A}=A_x\mathbf{a}_x+A_y\mathbf{a}_y+A_z\mathbf{a}_z \qquad \mathbf{B}=B_x\mathbf{a}_x+B_y\mathbf{a}_y+B_z\mathbf{a}_z$

Then $\mathbf{A}\times\mathbf{B}=\begin{vmatrix}\mathbf{a}_x & \mathbf{a}_y & \mathbf{a}_z\\ A_x & A_y & A_z\\ B_x & B_y & B_z\end{vmatrix}$

$$=\mathbf{a}_x(A_yB_z-A_zB_y)+\mathbf{a}_y(A_zB_x-A_xB_z)+\mathbf{a}_z(A_xB_y-A_yB_x)$$

$$\mathbf{A} \bullet (\mathbf{B} \times \mathbf{C}) = \mathbf{B} \bullet (\mathbf{C} \times \mathbf{A}) = \mathbf{C} \bullet (\mathbf{A} \times \mathbf{B})$$

$$\mathbf{A} \times (\mathbf{B} \times \mathbf{C}) \neq (\mathbf{A} \times \mathbf{B}) \times \mathbf{C}$$

In Cartesian coordinates :

$$\text{Then} \quad \underbrace{\mathbf{A} \bullet (\mathbf{B} \times \mathbf{C})}_{\textbf{A Scalar}} = \begin{vmatrix} A_x & A_y & A_z \\ B_x & B_y & B_z \\ C_x & C_y & C_z \end{vmatrix}$$

$$= A_x(B_yC_z - B_zC_y) + A_y(B_xC_z - B_zC_x) + A_z(\,??\,)$$

Vector Operations

Example

In Cartesian coordinates, vector **A** points from the origin to point $P_1 = (2,3,3)$, and vector **B** is directed from P_1 to point $P_2 = (1,-1,2)$.

Find:

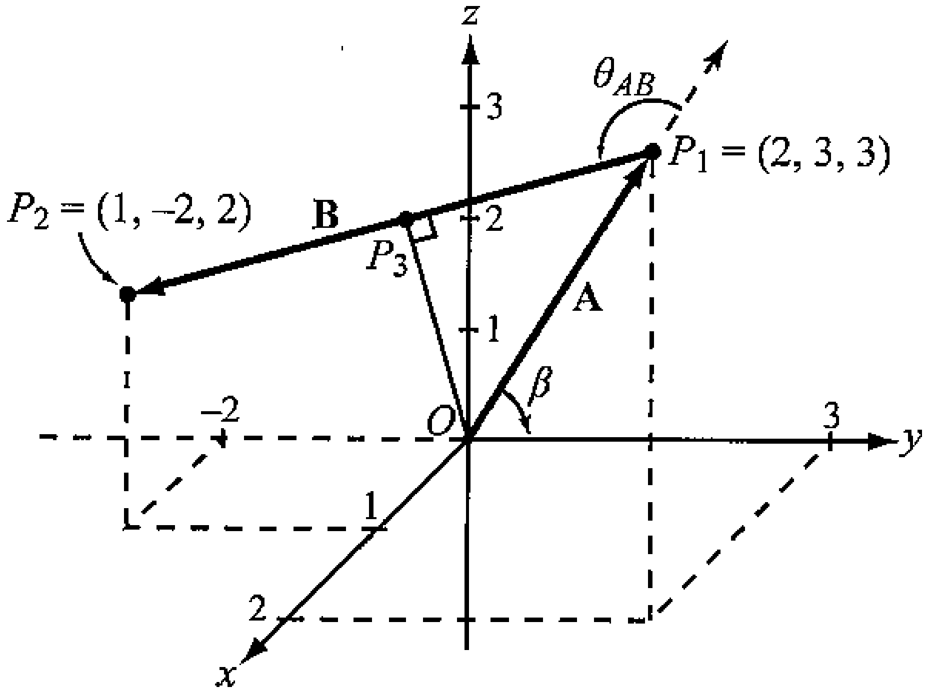
a) vector **A**: magnitude A and unit vector $\mathbf{a}_A$

b) the angle between **A** and the y-axis

c) vector **B**

d) the angle between **A** and **B**, and

e) the perpendicular distance from the origin to vector **B**.



Vector Operations

Example Solution

a) Vector $\mathbf{A}$ is given by the position vector of $P_1(2,3,3)$:

$$\mathbf{A} = 2\mathbf{a}_x + 3\mathbf{a}_y + 3\mathbf{a}_z$$

The magnitude: $A = |\mathbf{A}| = \sqrt{2^2 + 3^2 + 3^2} = \sqrt{22} = 4.69$

The unit vector: $\mathbf{a}_A = \dfrac{\mathbf{A}}{|\mathbf{A}|} = \dfrac{2\mathbf{a}_x + 3\mathbf{a}_y + 3\mathbf{a}_z}{4.69} = 0.43\mathbf{a}_x + 0.64\mathbf{a}_y + 0.64\mathbf{a}_z$

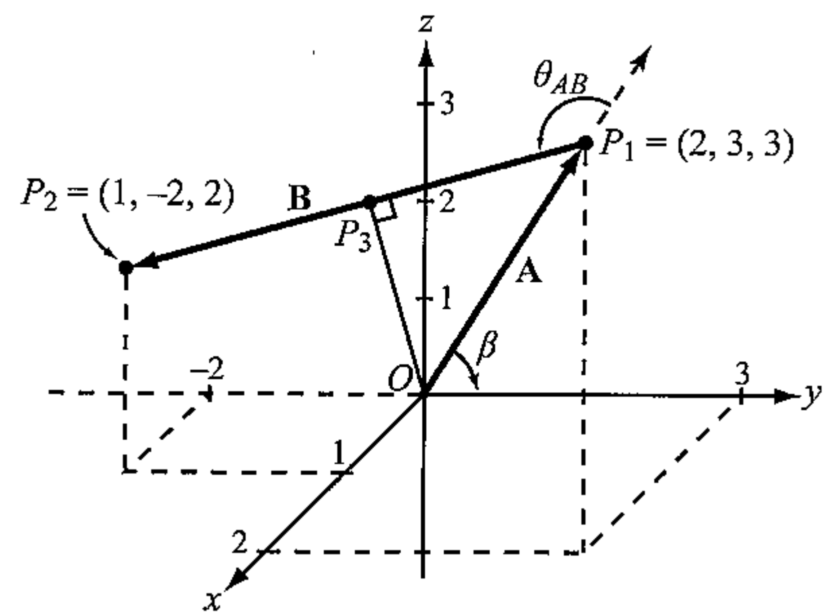
b) The angle between $\mathbf{A}$ and the y-axis:

$$\mathbf{A} \bullet \mathbf{a}_y = |\mathbf{A}||\mathbf{a}_y| \cos\beta = A\cos\beta$$

$$\beta = \cos^{-1}\left(\frac{\mathbf{A} \bullet \mathbf{a}_y}{A}\right) = \cos^{-1}\left(\frac{3}{4.69}\right) = 50.2^0$$

c) $\mathbf{B} = (1-2)\mathbf{a}_x + (-2-3)\mathbf{a}_y + (2-3)\mathbf{a}_z$

$$= -\mathbf{a}_x - 5\mathbf{a}_y - \mathbf{a}_z$$



d) $\mathbf{A} \bullet \mathbf{B} = AB\cos\theta_{AB}$

$$\mathbf{A} \bullet \mathbf{B} = A_x B_x + A_y B_y + A_z B_z = 2\times(-1) + 3\times(-5) + 3\times(-1) = -20$$

$$B = |\mathbf{B}| = \sqrt{(-1)^2 + (-5)^2 + (-1)^2} = \sqrt{27} = 5.20$$

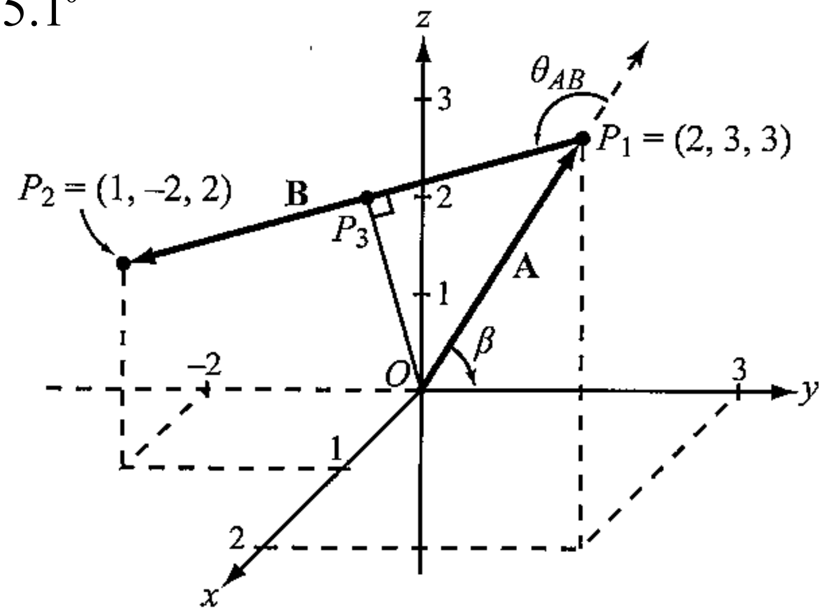
$$\theta_{AB} = \cos^{-1}\left(\frac{\mathbf{A} \bullet \mathbf{B}}{AB}\right) = \cos^{-1}\left(\frac{-20}{4.69\times 5.20}\right) = 145.1^0$$

e) The perpendicular distance from the origin to vector $\mathbf{B}$ is the distance $|\mathbf{OP}_3|$.

From the right triangle OP_1P_3 :

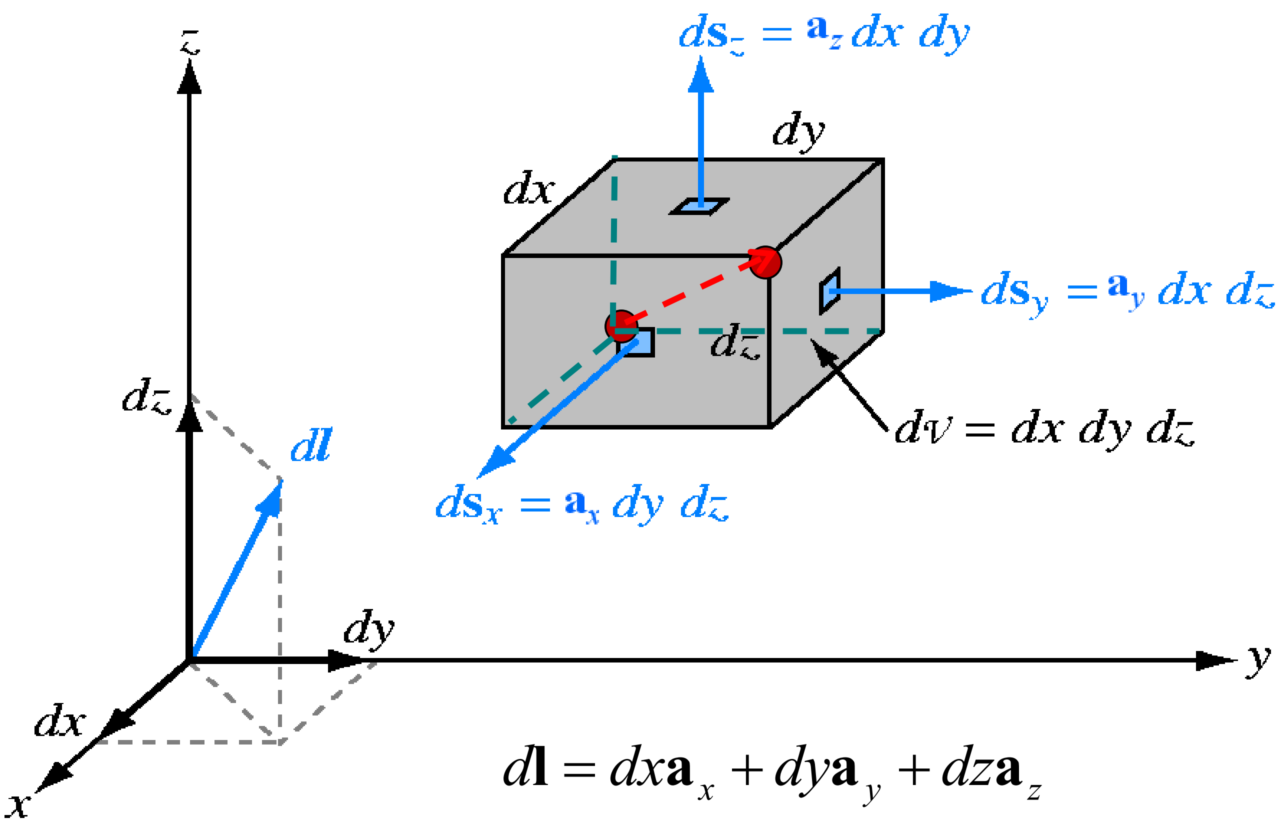
$$|\mathbf{OP}_3| = |\mathbf{A}|\sin(180^0 - \theta_{AB})$$

$$= 4.69\sin(180^0 - 145.1^0) = 2.68$$



Orthogonal Coordinate Systems

Cartesian/Rectangular



$d\mathbf{l}$

$d\mathbf{s}$

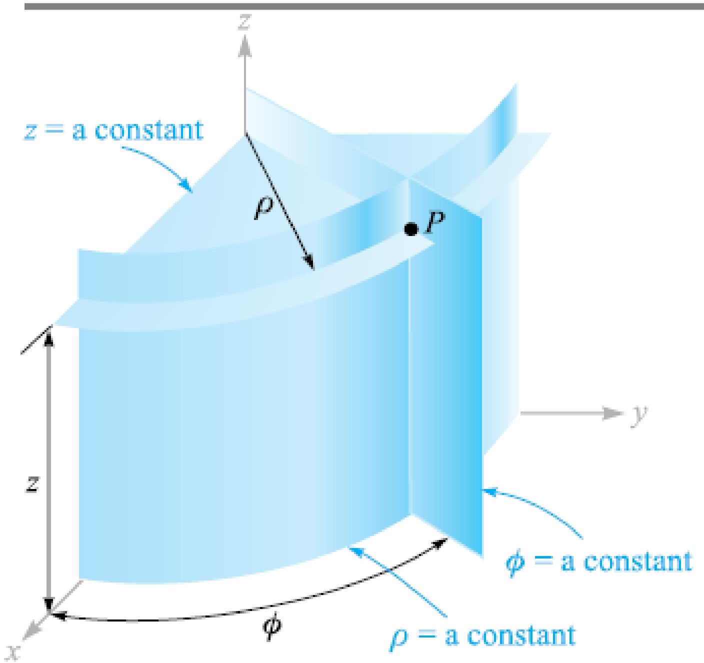
dv

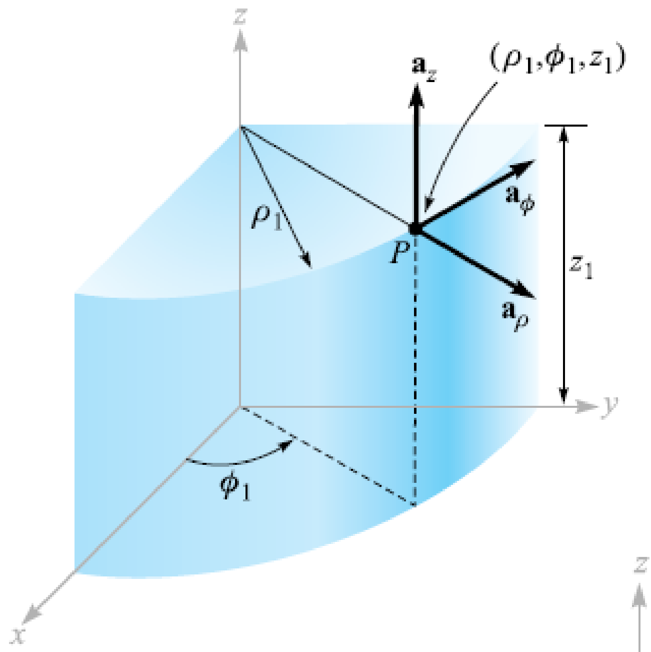
$$d\mathbf{l} = dx\mathbf{a}_x + dy\mathbf{a}_y + dz\mathbf{a}_z$$

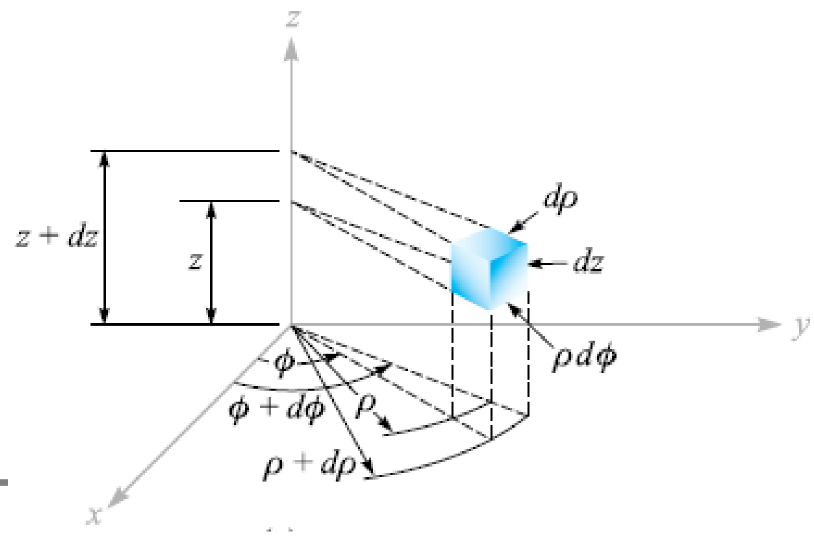
$$dl = \sqrt{dx^2 + dy^2 + dz^2}$$

Orthogonal Coordinate Systems

Cylindrical

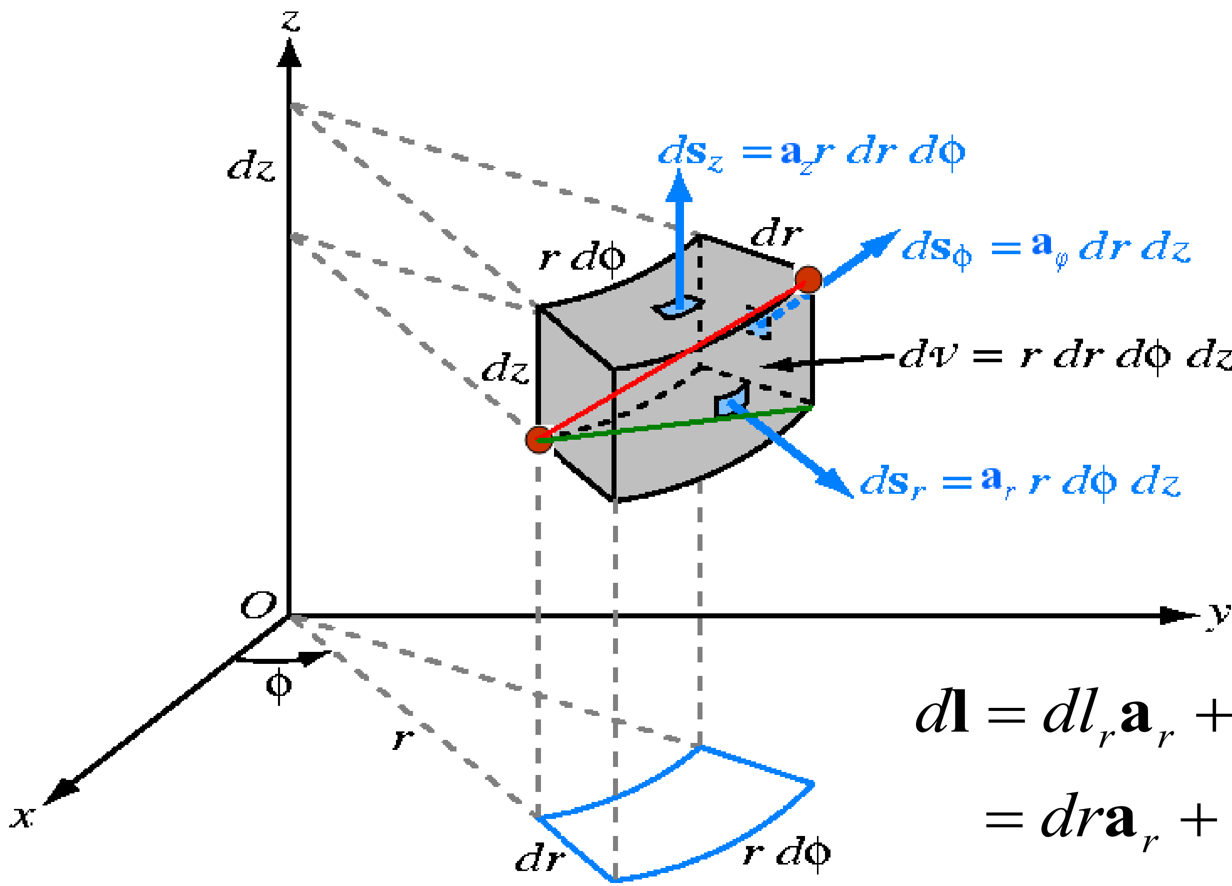






Orthogonal Coordinate Systems

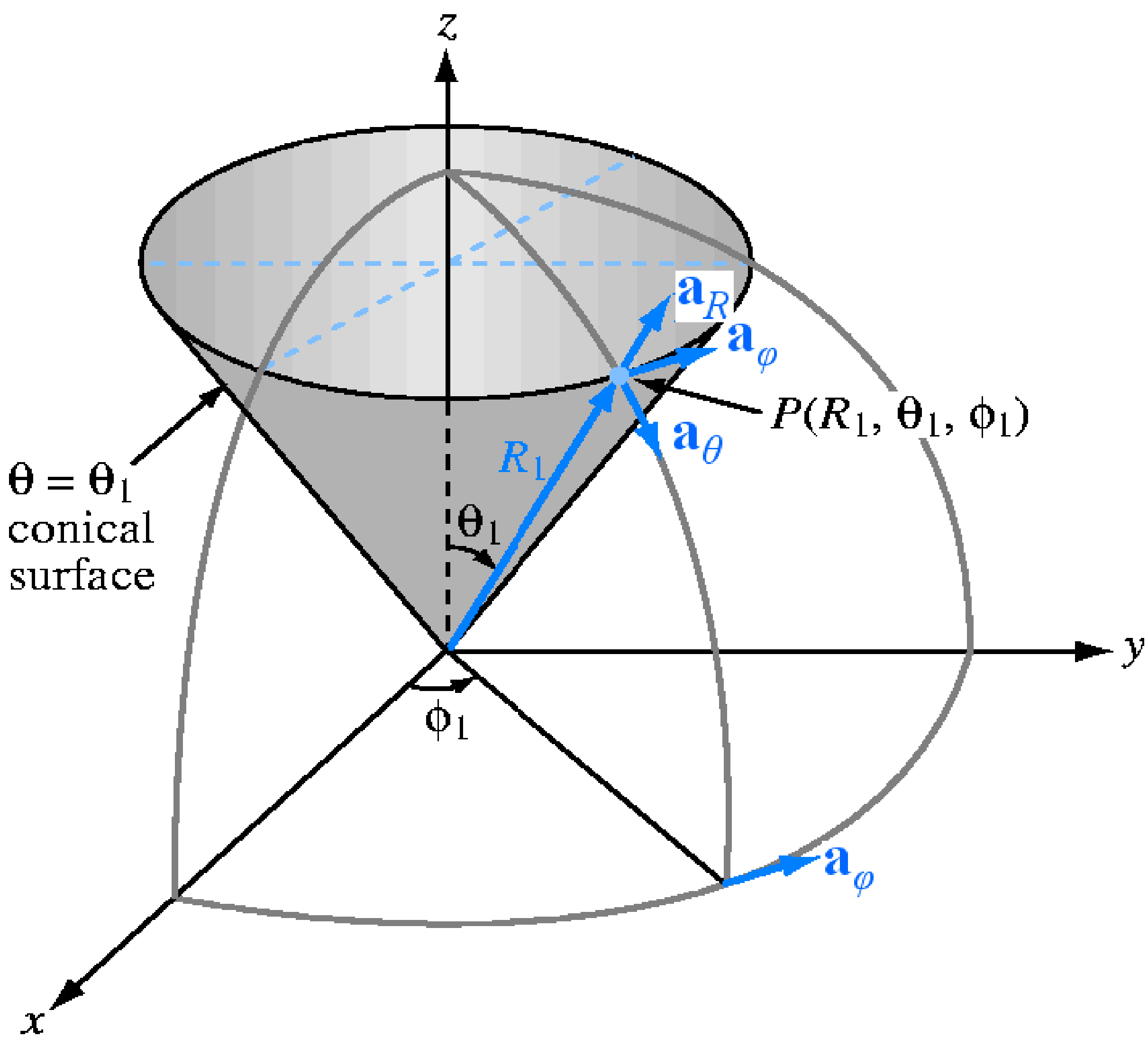
Cylindrical



$$d\mathbf{l} = dl_r \mathbf{a}_r + dl_\phi \mathbf{a}_\phi + dl_z \mathbf{a}_z$$
$$= dr\mathbf{a}_r + rd\phi\mathbf{a}_\phi + dz\mathbf{a}_z$$
$$dl = \sqrt{dr^2 + r^2 d\phi^2 + dz^2}$$
$$dv = dr \cdot (rd\phi) \cdot dz$$

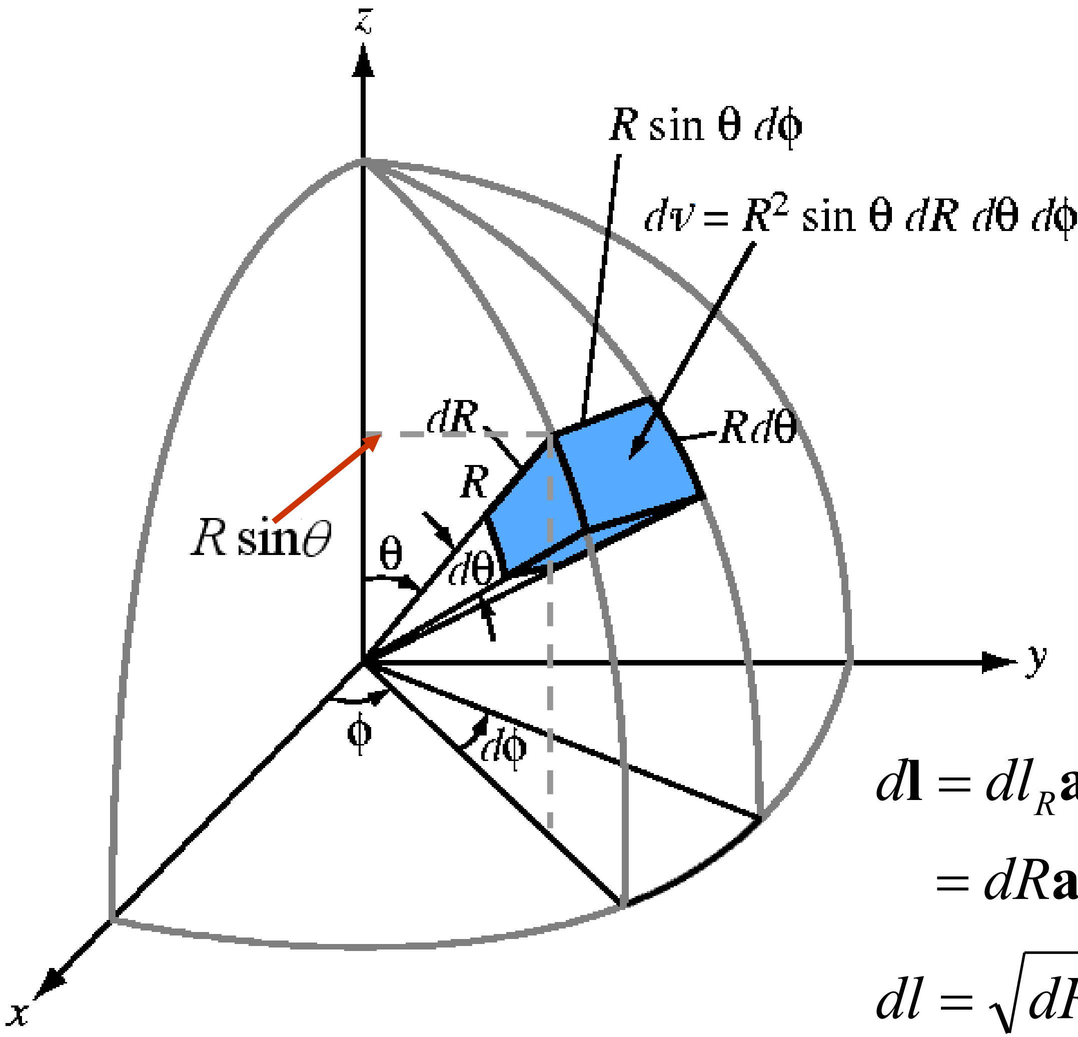
Orthogonal Coordinate Systems

Spherical



Orthogonal Coordinate Systems

Spherical



$$d\mathbf{l} = dl_R \mathbf{a}_R + dl_\theta \mathbf{a}_\theta + dl_\phi \mathbf{a}_\phi$$

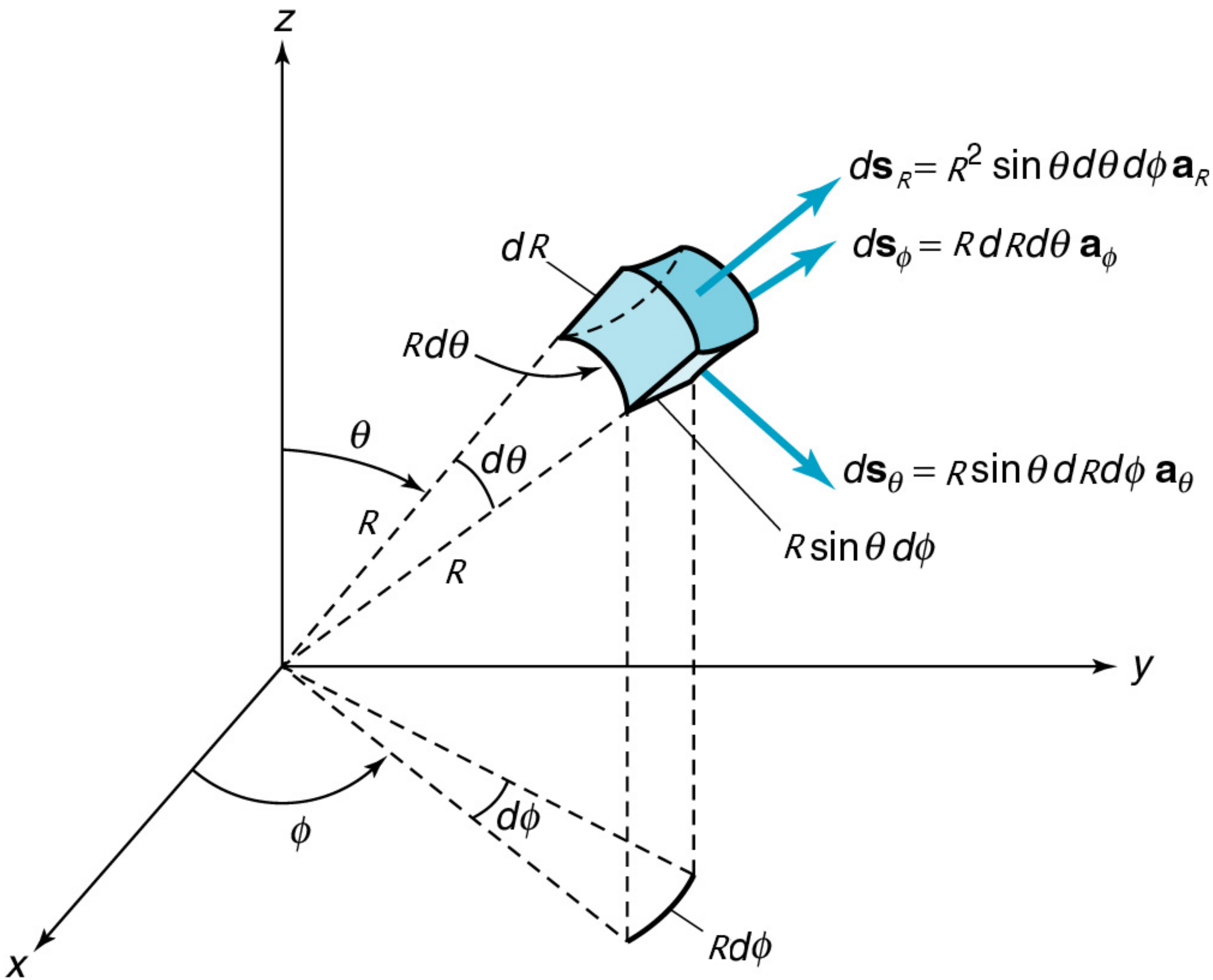
$$= dR\mathbf{a}_R + Rd\theta\mathbf{a}_\theta + R\sin\theta d\phi\mathbf{a}_\phi$$

$$dl = \sqrt{dR^2 + R^2 d\theta^2 + R^2 \sin^2\theta d\phi^2}$$

$$dv = dR \cdot (Rd\theta) \cdot (R\sin\theta d\phi)$$

Orthogonal Coordinate Systems

Spherical



Transformations

Transformations of Coordinate Variables

$$\text{Cartesian}: \quad x, \quad y \text{ and } z$$

$$\text{Cylindrical}: \quad r, \ \phi \ \text{ and } \ z$$

$$\text{Spherical}: \quad R, \ \theta \ \text{ and } \ \phi$$

$$\begin{array}{c} \text{Cartesian} \\ \boxed{\begin{array}{c} x \\ y \\ z \end{array}} \end{array} = \begin{array}{c} \text{Cylindrical} \\ \boxed{\begin{array}{l} r\cos\phi \\ r\sin\phi \\ z \end{array}} \end{array} = \begin{array}{c} \text{Spherical} \\ \boxed{\begin{array}{l} R\sin\theta\cos\phi \\ R\sin\theta\sin\phi \\ R\cos\theta \end{array}} \end{array}$$

Transformations of Unit Vectors

$$\text{Cartesian}: \quad \mathbf{a}_x, \ \mathbf{a}_y \ \text{ and } \ \mathbf{a}_z$$

$$\text{Cylindrical}: \quad \mathbf{a}_r, \ \mathbf{a}_\phi \ \text{ and } \ \mathbf{a}_z$$

$$\text{Spherical}: \quad \mathbf{a}_R, \ \mathbf{a}_\theta \ \text{ and } \ \mathbf{a}_\phi$$

$$\begin{array}{c} \text{Cartesian} \\ \boxed{\begin{array}{c} \mathbf{a}_x \\ \\ \mathbf{a}_y \\ \\ \mathbf{a}_z \end{array}} \end{array} = \begin{array}{c} \text{Cylindrical} \\ \boxed{\begin{array}{l} \mathbf{a}_r\cos\phi - \mathbf{a}_\phi\sin\phi \\ \\ \mathbf{a}_r\sin\phi + \mathbf{a}_\phi\cos\phi \\ \\ \mathbf{a}_z \end{array}} \end{array} = \begin{array}{c} \text{Spherical} \\ \boxed{\begin{array}{l} \mathbf{a}_R\sin\theta\cos\phi + \\ \mathbf{a}_\theta\cos\theta\cos\phi - \mathbf{a}_\phi\sin\phi \\ \mathbf{a}_R\sin\theta\sin\phi + \\ \mathbf{a}_\theta\cos\theta\sin\phi + \mathbf{a}_\phi\cos\phi \\ \mathbf{a}_R\cos\theta - \mathbf{a}_\theta\sin\theta \end{array}} \end{array}$$

Vector in the Three Coordinates

	Cartesian	Cylindrical	Spherical
Vector $\mathbf{A}$	$\mathbf{a}_x A_x + A_y\,\mathbf{a}_y + A_z\,\mathbf{a}_z$		
Magnitude of $\mathbf{A}$	$\sqrt{A_x^2 + A_y^2 + A_z^2}$		
Unit vector properties	$\mathbf{a}_x \bullet \mathbf{a}_x = \mathbf{a}_y \bullet \mathbf{a}_y = \mathbf{a}_z \bullet \mathbf{a}_z = 1$ $\mathbf{a}_x \bullet \mathbf{a}_y = \mathbf{a}_y \bullet \mathbf{a}_z = \mathbf{a}_z \bullet \mathbf{a}_x = 0$ $\mathbf{a}_x \times \mathbf{a}_y = \mathbf{a}_z, \quad \mathbf{a}_y \times \mathbf{a}_z = \mathbf{a}_x$ $\mathbf{a}_z \times \mathbf{a}_x = \mathbf{a}_y$		
$\mathbf{A} \bullet \mathbf{B}$	$A_x B_x + A_y B_y + A_z B_z$		
$\mathbf{A} \times \mathbf{B}$	$\begin{vmatrix} \mathbf{a}_x & \mathbf{a}_y & \mathbf{a}_z \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$		

Summary of Vector Relations

	Cartesian Coordinates	Cylindrical Coordinates	Spherical Coordinates
Coordinate variables	x, y, z	r, ϕ, z	R, θ, ϕ
Vector representation, A	$\mathbf{a}_x A_x + A_y\, \mathbf{a}_y + A_z\, \mathbf{a}_z$	$\mathbf{a}_r A_r + A_\phi\, \mathbf{a}_\phi + A_z\, \mathbf{a}_z$	$\mathbf{a}_R A_R + A_\theta\, \mathbf{a}_\theta + A_\phi\, \mathbf{a}_\phi$
Magnitude of A, $\lvert A\rvert$	$+\sqrt{A_x^2 + A_y^2 + A_z^2}$	$+\sqrt{A_r^2 + A_\phi^2 + A_z^2}$	$+\sqrt{A_R^2 + A_\theta^2 + A_\phi^2}$
Base vectors properties	$\mathbf{a}_x \bullet \mathbf{a}_x = \mathbf{a}_y \bullet \mathbf{a}_y = \mathbf{a}_z \bullet \mathbf{a}_z = 1$ $\mathbf{a}_x \bullet \mathbf{a}_y = \mathbf{a}_y \bullet \mathbf{a}_z = \mathbf{a}_z \bullet \mathbf{a}_x = 0$ $\mathbf{a}_x \times \mathbf{a}_y = \mathbf{a}_z, \quad \mathbf{a}_y \times \mathbf{a}_z = \mathbf{a}_x$ $\mathbf{a}_z \times \mathbf{a}_x = \mathbf{a}_y$	$\mathbf{a}_r \bullet \mathbf{a}_r = \mathbf{a}_\phi \bullet \mathbf{a}_\phi = \mathbf{a}_z \bullet \mathbf{a}_z = 1$ $\mathbf{a}_r \bullet \mathbf{a}_\phi = \mathbf{a}_\phi \bullet \mathbf{a}_z = \mathbf{a}_z \bullet \mathbf{a}_r = 0$ $\mathbf{a}_r \times \mathbf{a}_\phi = \mathbf{a}_z, \quad \mathbf{a}_\phi \times \mathbf{a}_z = \mathbf{a}_r$ $\mathbf{a}_z \times \mathbf{a}_r = \mathbf{a}_\phi$	$\mathbf{a}_R \bullet \mathbf{a}_R = \mathbf{a}_\theta \bullet \mathbf{a}_\theta = \mathbf{a}_\phi \bullet \mathbf{a}_\phi = 1$ $\mathbf{a}_R \bullet \mathbf{a}_\theta = \mathbf{a}_\theta \bullet \mathbf{a}_\phi = \mathbf{a}_\phi \bullet \mathbf{a}_R = 0$ $\mathbf{a}_R \times \mathbf{a}_\theta = \mathbf{a}_\phi, \quad \mathbf{a}_\theta \times \mathbf{a}_\phi = \mathbf{a}_R$ $\mathbf{a}_\phi \times \mathbf{a}_R = \mathbf{a}_\theta$
Dot product, A · B	$A_x B_x + A_y B_y + A_z B_z$	$A_r B_r + A_\phi B_\phi + A_z B_z$	$A_R B_R + A_\theta B_\theta + A_\phi B_\phi$
Cross product, A × B	$\begin{vmatrix} \mathbf{a}_x & \mathbf{a}_y & \mathbf{a}_z \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$	$\begin{vmatrix} \mathbf{a}_x & \mathbf{a}_\phi & \mathbf{a}_z \\ A_r & A_\phi & A_z \\ B_r & B_\phi & B_z \end{vmatrix}$	$\begin{vmatrix} \mathbf{a}_R & \mathbf{a}_\theta & \mathbf{a}_\phi \\ A_R & A_\theta & A_\phi \\ B_R & B_\theta & B_\phi \end{vmatrix}$

Summary

Vector calculus:

Addition and subtraction
Dot product
Cross product

Coordinate systems:

Cartesian/Rectangular (x, y, z)
Cylindrical (r, φ, z)
Spherical (R, θ, φ)

Book: Electromagnetism And Electromechanics

Chapter 1: Vector Analysis

Next Lecture

Vectors

- Line Integral
- Surface Integral
- Fields

Electric Fields

Thanks for your attendance