Physical Quantity

Eung Je Woo

Department of Biomedical Engineering

Impedance Imaging Research Center (IIRC)

Kyung Hee University

Korea

ejwoo@khu.ac.kr

Fundamental Quantity

- Length (dimension or size) in meter (m)
- Time (sequence or duration or interval) in second (s)
- Mass in kilogram (kg)
- Charge in coulomb (C)
- Temperature in kelvin (K)
- Amount of substance in mole (mol)
- Luminous intensity in candela (cd)

Unit

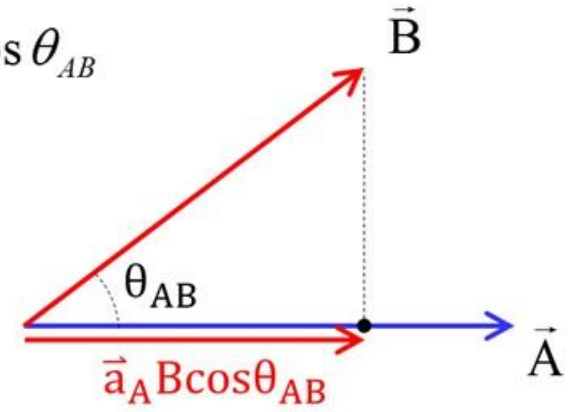
unit	symbol	MKS (abbrev.)	cgs (abbrev.)
acceleration	a	m s^{-2}	Gal
capacitance	C	Farad (F)	cm
charge	q	Coulomb (C)	esu
current	I	Ampere (A)	esu s^{-1}
electric field	E	V m^{-1}	statvolt cm^{-1}
electric potential	V, ϕ	Volt (V)	statvolt
energy, work	E, W	Joule (J)	erg
force	F	Newton (N)	dyne
inductance	L	Henry (H)	cm^{-1} s^{2}
length	l, d	meter (m)	centimeter (cm)
magnetic field	B	Tesla (T)	Gauss (G)
magnetic flux	Φ_B	Weber (w)	Gauss cm^{2}
mass	m	kilogram (kg)	gram (g)
momentum	p	kg m s^{-1}	g cm s^{-1}
power	P	Watt (W)	erg s^{-1}
pressure	P	Pascal (Pa)	bar
resistance	R	Ohm (Ω)	cm^{-1} s
temperature	T	Kelvin (K)	Kelvin (K)
time	t	second (s)	second (s)
velocity	v	m s^{-1}	cm s^{-1}

Scalar, Vector, Space, Time and Dimension

- Scalar
  - A quantity that has only magnitude
- Vector
  - A quantity that has both magnitude and direction
  - In general, a quantity that is expressed as multiple values
- Space
  - What is space?
- Time
  - What is time?
- Dimension
  - A minimal number of independent values used to express a quantity

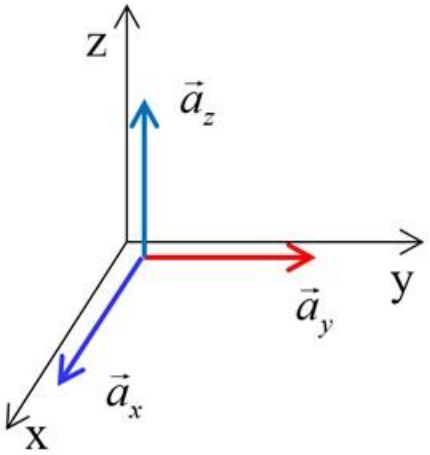
Dot Product (Scalar Product)

$$\vec{A} \cdot \vec{B} \equiv AB \cos\theta_{AB}$$



$$\left.\begin{array}{l} \vec{A} = (A_x, A_y, A_z) \\ \vec{B} = (B_x, B_y, B_z) \end{array}\right\} \rightarrow \vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z$$

Dot Product (Scalar Product)



(i) Commutative law:

$$\vec{A}\cdot\vec{B}=\vec{B}\cdot\vec{A}$$

(ii) Associative law

$$\vec{A}\cdot(\vec{B}\cdot\vec{C})=(\vec{A}\cdot\vec{B})\cdot\vec{C}$$

(iii) Distributive law:

$$\vec{A}\cdot(\vec{B}+\vec{C})=\vec{A}\cdot\vec{B}+\vec{A}\cdot\vec{C}$$

$$\vec{A}\cdot\vec{A}=|\vec{A}|^2=A^2$$

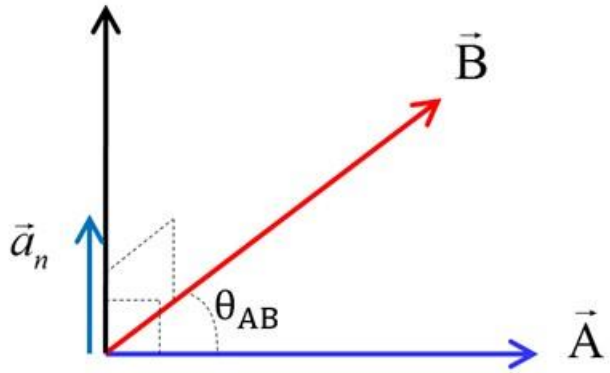
(iv) Note :

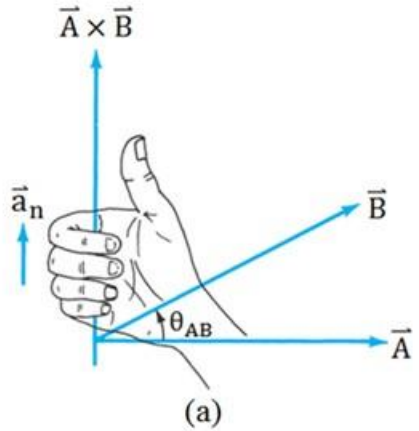
$$\vec{a}_x\cdot\vec{a}_y=\vec{a}_y\cdot\vec{a}_z=\vec{a}_z\cdot\vec{a}_x=0$$

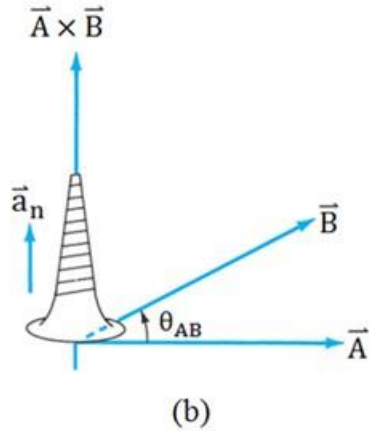
$$\vec{a}_x\cdot\vec{a}_x=\vec{a}_y\cdot\vec{a}_y=\vec{a}_z\cdot\vec{a}_z=1$$

Cross Product (Vector Product)

$$\vec{A}\times\vec{B}\equiv AB\sin\theta_{AB}\vec{a}_n$$







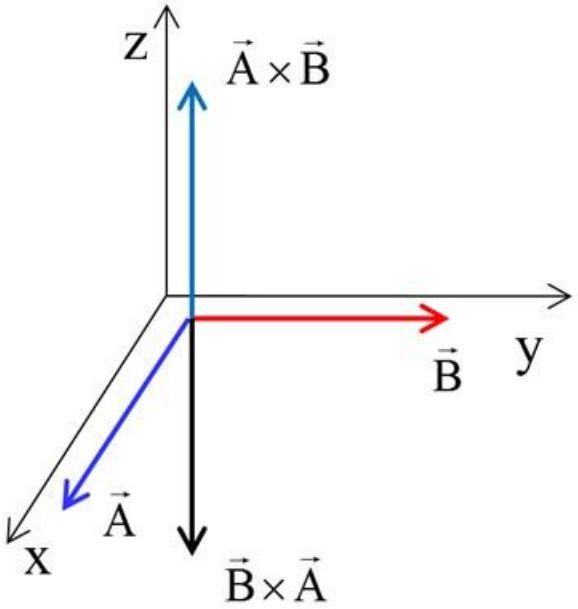
$$\vec{A}=(A_x,A_y,A_z)\ \text{ and }\ \vec{B}=(B_x,B_y,B_z)$$

$$\vec{A}\times\vec{B}=\begin{vmatrix}\vec{a}_x & \vec{a}_y & \vec{a}_z\\ A_x & A_y & A_z\\ B_x & B_y & B_z\end{vmatrix}=(A_yB_z-A_zB_y)\vec{a}_x-(A_xB_z-A_zB_x)\vec{a}_y+(A_xB_y-A_yB_x)\vec{a}_z$$

Cross Product (Vector Product)

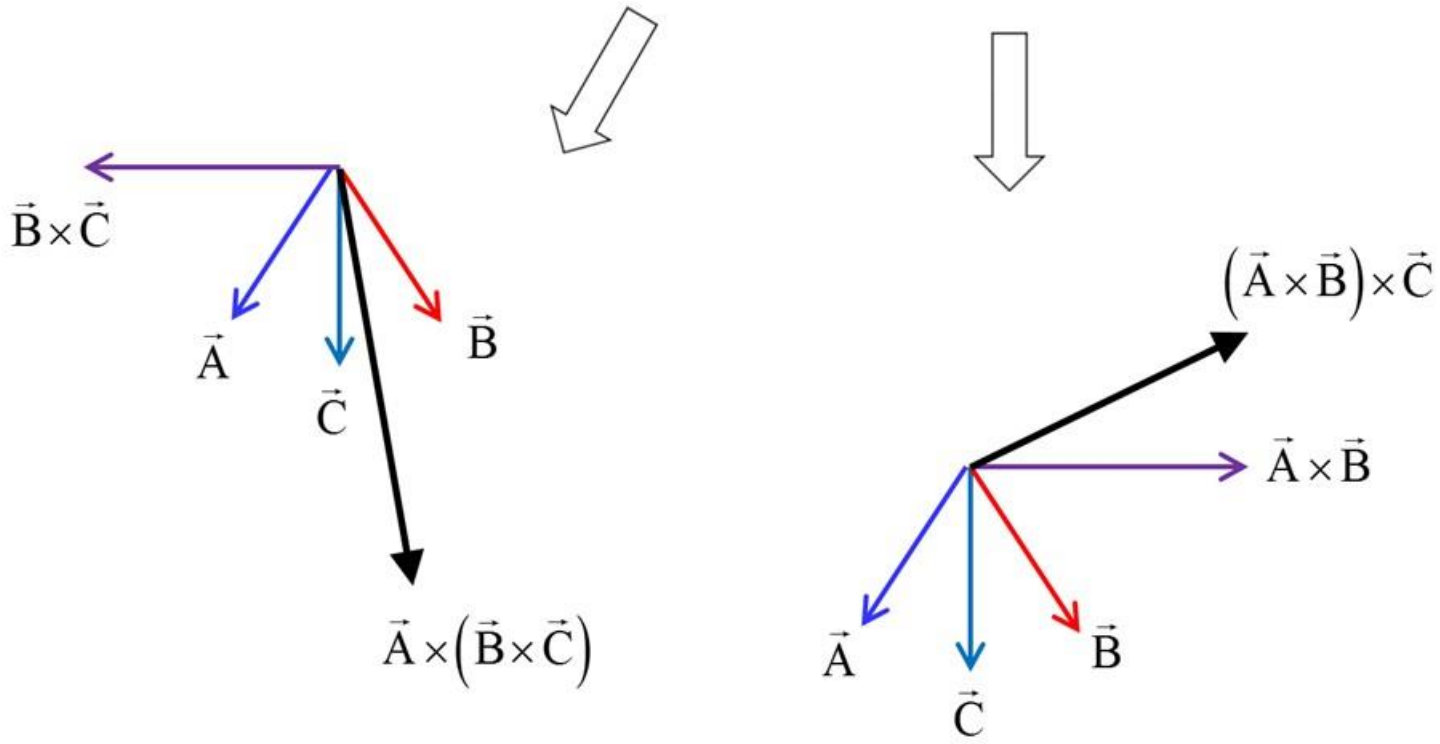
(i) It is not commutative: $\vec{A} \times \vec{B} \neq \vec{B} \times \vec{A}$

It is anti-commutative: $\vec{A} \times \vec{B} = -\vec{A} \times \vec{B}$



Cross Product (Vector Product)

(ii) It is not associative: $\vec{A}\times\left(\vec{B}\times\vec{C}\right)\neq\left(\vec{A}\times\vec{B}\right)\times\vec{C}$



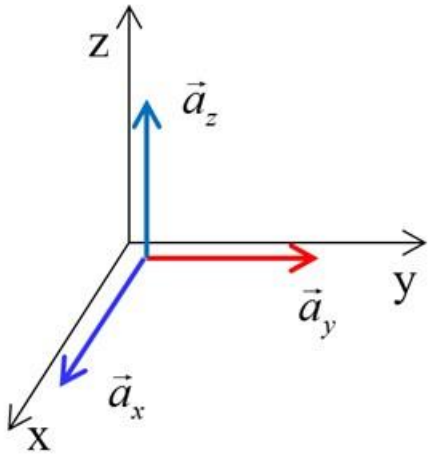
Cross Product (Vector Product)

(iii) It is distributive: $\vec{A}\times(\vec{B}+\vec{C})=\vec{A}\times\vec{B}+\vec{A}\times\vec{C}$

(iv) Note

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

$$\begin{cases}\vec{a}_x\times\vec{a}_y=\vec{a}_z\\ \vec{a}_y\times\vec{a}_z=\vec{a}_x\\ \vec{a}_z\times\vec{a}_x=\vec{a}_y\end{cases}\qquad\begin{cases}\vec{a}_x\times\vec{a}_x=\vec{0}\\ \vec{a}_y\times\vec{a}_y=\vec{0}\\ \vec{a}_z\times\vec{a}_z=\vec{0}\end{cases}$$



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