PPP0101
PRINCIPLES OF PHYSICS

Foundation in Information

Technology

ONLINE NOTES

Chapter 1
Physical Quantities and Vectors

1.1 Introduction to Physics in Information Technology

1. Physics is the most basic of the sciences. It deals with the behavior and structure of matter.
2. Physics is usually divided into classic physics and modern physics

- Motion
- Fluids
- Heat
- Sound
- Light
- Electricity
- Magnetism

- Relativity
- Atomic Structure
- Condensed Matter
- Nuclear Physics
- Elementary Particles
- Cosmology
- Astrophysics

3. An understanding of physics is crucial for anyone making a career in information technology (IT).
4. The familiar devices that we use to collect, transform, transmit and interact with electronic information operate sparingly close to very many fundamental physical limits.

Example Application That Related to IT and Physics	
A handheld GPS receiver requires special and general relativistic correction to the time reported by the system's atomic clock	The typical distance between air molecules in a hard disk is larger than the height that the head flies above the platter
Linewidth in a VLSI circuit is approaching the size of a single atom	The performance of satellite receivers is limited by the echo of the Big Bang.

5. Given the economic and intellectual importance of these scaling limits, surprisingly few people are equipped to address them.
6. Therefore, understanding how such device work, how they can or cannot be improved, requires deep insight into the character of physical law as well as engineering practice.
7. Physics knowledge that you are going to learn in this course provide the needed connection by introducing underlying governing equation and then deriving operational device principles.
8. This self-contained volume will help computer scientists see beyond the conventional division between hardware and software to understand the implication of physical theory for information manipulation

1.2 Quantity

Introduction to SI Units

1. Objects and phenomena are measured and described using standard units, a group of which makes up a system of units.
2. The International System of Units (SI), or the metric system, consists of seven (see table 1) base units.

QUANTITY	SI UNITS	SYMBOL
Length	**meter**	**m**
Mass	**kilogram**	**kg**
Time	**second**	**s**
Electric current	**ampere**	**I**
Temperature	**kelvin**	**K**
Luminous Intensity	**candela**	**cd**
Amount of Substance	**mol**	**mol**

Table 1: Base Units

Derived Units

1. These units are derived from the base units
2. These units are form by combination of base units.

QUANTITY	UNIT	ABBREVIATION	IN TERMS OF BASE UNITS
Force	Newton	N	$kg\ ms^{-2}$
Energy & Work	Joule	J	$kg.m^2s^{-2}$
Power	Watt	W	$kg.m^2s^{-2}$
Pressure	Pascal	Pa	$kg/(m.s^2)$

Electric Charge	Coulomb	C	A.s
Electric Potential	Volt	V	$kg.m^2/(A.s^3)$
Electric Resistance	Ohm	Ω	$kg.m^2/(A^2.s^3)$
Capacitance	Farad	F	$A^2.s^4/(kg.m^2)$
Inductance	Henry	H	$kg.m^2/(s^2.A^2)$
Magnetic Flux	Weber	Wb	$kg.m^2/(A.\ s^2)$

1.3 Standard Prefixes

1. It is used to denote multiples of ten.

FACTOR	PREFIX	*SYMBOL*	FACTOR	PREFIX	SYMBOL
10^{18}	**Exa**	E	$\mathbf{10^{-1}}$	**deci**	d
10^{15}	**Peta**	P	$\mathbf{10^{-2}}$	**Centi**	c
10^{12}	**Tera**	T	$\mathbf{10^{-3}}$	**Milli**	m
10^{9}	**Giga**	G	$\mathbf{10^{-6}}$	**Micro**	μ
10^{6}	**Mega**	M	$\mathbf{10^{-9}}$	**Nano**	n
10^{3}	**Kilo**	k	$\mathbf{10^{-12}}$	**Pico**	p
10^{2}	**Hecto**	h	$\mathbf{10^{-15}}$	**Femto**	f
10^{1}	**deka**	da	$\mathbf{10^{-18}}$	**Ato**	a

Example

Express the following with standard prefixes.

$1.2\times10^{-12}\ F = 1.2\ \text{pF}$

$2.9\times10^{-6} Hz = 2.9 \mu Hz$

Example

The fourteen tallest peaks in the world are referred to as "eight-thousanders", meaning their summits are over 8000 m above sea level. What is the elevation , in kilo and nano, of an elevation of 8000 m ?

$$1000m = 1km$$
$$1m = \frac{1}{1000}km$$
$$(8000\times1)m = \left(8000\frac{1}{1000}\right)km$$
$$= 8km$$

$$1m = \left(1\times10^9\right)nm$$
$$(8000\times1)m = \left(8000\times1\times10^9\right)nm$$
$$= 8\times10^{12}\ nm$$

1.4 Dimension

1. Dimension is used to refer to the physical nature of a quantity and the type of unit used to specify it.
2. Many physical quantities can be expressed in terms of a combination of fundamental dimensions such as length (L), time (T) and mass (M).
3. Symbol for dimension of a physical quantity is **[quality].**

QUANTITY	DIMENSION	SYMBOL
Mass	[mass]	M
Length	[length]	L
Time	[time]	T
Velocity	[length] / [time]	LT^{-1}
Acceleration	[velocity] / [time]	LT^{-2}
Force	[mass] × [acceleration]	MLT^{-2}
Surface Tension	[force] / [length]	MT^{-2}
Pressure	[force] / [area]	$ML^{-1}T^{-2}$
Work / Power Energy	[force] × [distance]	$ML^{2}T^{-2}$
Power	[work] / [time]	$ML^{2}T^{-3}$

Table 4: Dimension of several quantities

4. There is no dimension for,
    a. Numerical value
    b. Ratio between the same quantity
    c. Angle has no dimension because it is a comparison between two position of length measurement.
    d. Known constant. For example: ln, lg and π.
        i. But, there are some constant has a dimension. For example, Modulus Young, Gravitational acceleration.
5. The objective of dimension analysis is:
    a. Check whether an equation is dimensionally correct, i.e., if an equation has the same dimension (unit) on both sides.
    b. Derive an equation
    c. Find out dimension or units of derived quantities.

Note: **Dimensionally correct does not necessarily mean the equation is correct.**

1.5 Vector

Scalar Quantity

1. A scalar quantity, or scalar, is one that has nothing to do with spatial direction.
2. Many physical concepts such as length, time temperature, mass, density, charge and volume are scalars; each has a scale or size but no associated direction.

3. The number of students in a class, the quantity of sugar in a jar, and the cost of a house are familiar scalar quantities.
4. Scalars are specified by ordinary number and add and subtract in the usual way.

Vector Quantity

1. Vector quantities have magnitude and direction.
2. Physical quantities that have both numerical and directional properties are represented by vectors. Examples of vector quantities are force, momentum, velocity, displacement and acceleration.

Introduction to Vector

1. In printed material, vectors are often represented by boldface type, such as **F**.
2. When written by hand, the designations $\vec{F}$ is commonly used.
3. The magnitude of vector a is written as a or $|a|$.

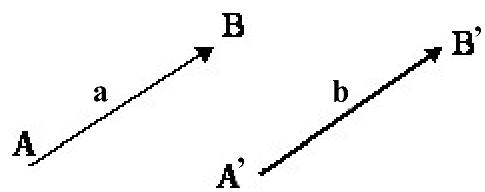


Figure 1: Vector AB and A'B'

4. Figure 1shows 2 vectors, namely Vector AB and A'B'. Below is the analysis of both vectors:
   a. Vector **AB** and **A'B'** are identical if both vector has
      i. Same length
      ii. Same direction.
   b. Two vectors **a** and **b** are equal only if:
      i. $|a| = |b|$
      ii. direction of **a** = direction of **b**

Graphical Addition of Vectors

1. To represent a vector on a diagram, we draw an arrow
   a. Choose a scale. Example: 1 cm :1 km
   b. Choose the length of the arrow proportional to the magnitude of the vector.

1.6.1.1 Triangle Method

1. Draw vector **A** with its magnitude represented by a convenient scale.
2. Draw vector **B** to the same scale , its tail start from tip of A

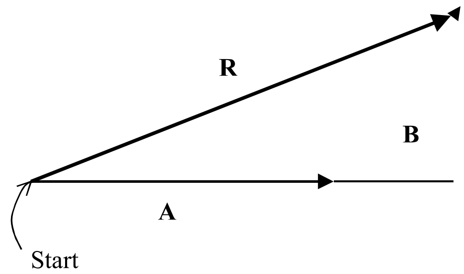


Figure 2: Vector with Triangle Method

3. Resultant vector , **R = A + B** drawn from the tail of **A** to the tip of **B**, as in figure 2.

<u>Polygon Method</u>

1. This method for finding the resultant $\vec{R}$ of several vectors ($\vec{A}$, $\vec{B}$ and $\vec{C}$) consists in beginning at any convenient point and drawing (to scale and in the proper directions) each vector arrow in turn.
2. They may be taken in any order of succession: $\vec{A}+\vec{B}+\vec{C}=\vec{C}+\vec{B}+\vec{A}=\vec{R}$.
3. The tail end of each arrow is positioned at the tip end of the preceding one, as shown in figure 3.

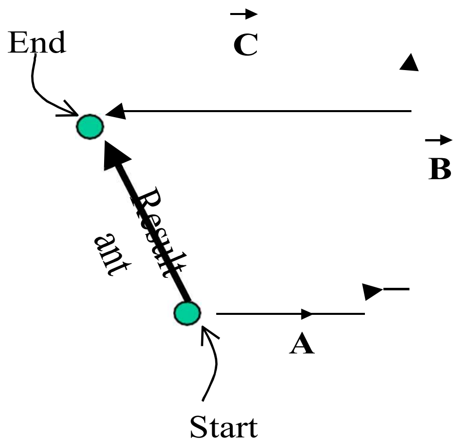


Figure 3: Vector with Polygon Method

4. The resultant is represented by an arrow with its tail end at the starting point and its tip end at the tip of the last vector added. If $\vec{R}$ is the resultant, R = $|\vec{R}|$ is the size or magnitude of the resultant.

Parallelogram Method

1. For adding two vectors: the resultant of two vectors acting at any angle may be represented by the diagonal of a parallelogram.
2. The two vector are drawn as the sides of the parallelogram and the resultant is its diagonal, as shown in figure 4.
3. The direction of the resultant is away from the origin of the two vectors.

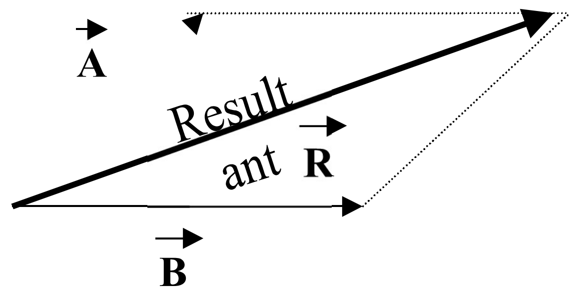


Figure 4: Vector with Parallelogram Method

Graphical Subtraction of Vectors

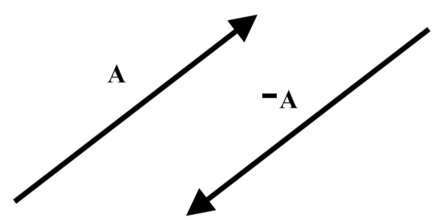
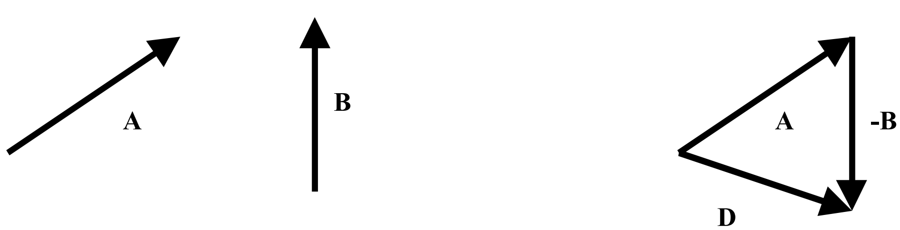


Figure 5: Vector with inverse magnitude

1. Vector –A means
   a. Same magnitude as A but opposite direction.
2. To subtract a vector $\vec{B}$ from $\vec{A}$, reverse the direction of $\vec{B}$ and add individually to vector $\vec{A}$, that is , $\vec{A} - \vec{B} = \vec{A} + (-\vec{B})$



A - B = A + (- B)

Figure 6: Subtraction of Vector

A Component of A Vector

1. A component of a vector is its effective value in a given direction.
2. For example, the x-component of a displacement is the displacement parallel to the x-axis caused by the given displacement.
3. A vector in three dimensions may be considered as the resultant of its component vectors resolved along any three *mutually perpendicular* directions.
4. Similarly, a vector in two dimensions may be resolved into two component vectors acting along any two mutually perpendicular directions.
5. The process of finding the components is known as resolving the vector into its components.

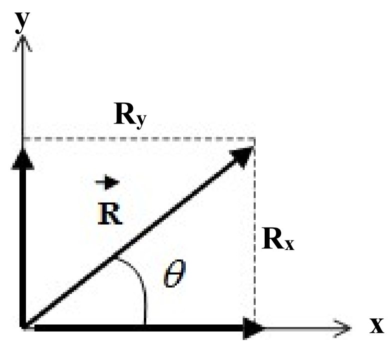
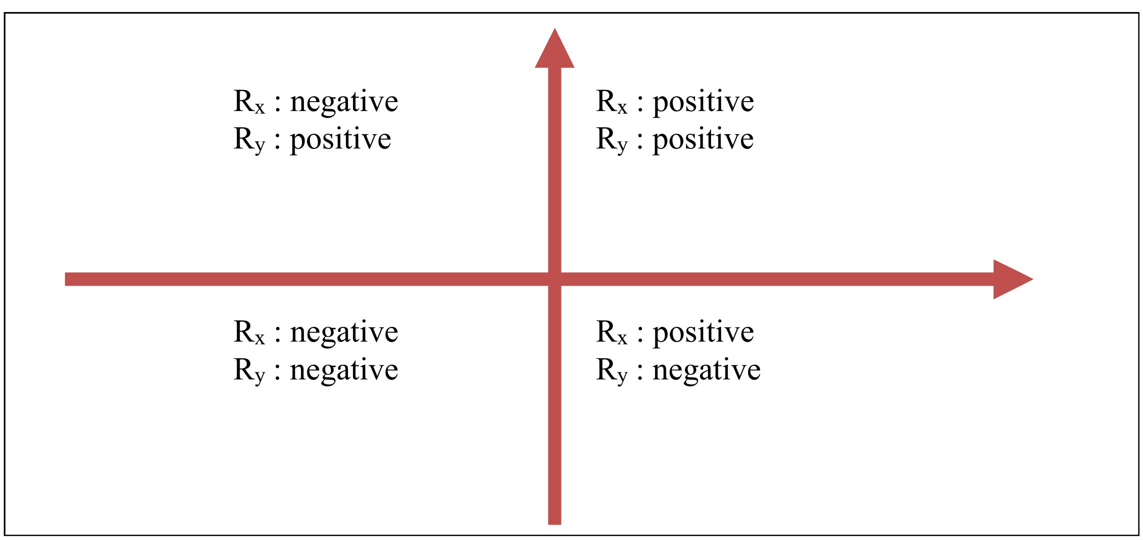


Figure 7: Vector with its x component and y component

6. Figure 7 shows the vector $\vec{R}$ and its x and y vector components $\vec{R}_X$ and $\vec{R}_Y$, which have magnitudes.

   x component is equal to $R_x = R\cos\theta$

   y component is equal to $R_y = R\sin\theta$



Any component that points along the negative x and y gets a negative sign.
Example: $\theta = 120^o$ **,** R_x **= negative and** R_y **= positive**

7. Each vector is resolved into its x- and y- components, with negatively directed components taken as negative.
8. The scalar x-component R_x of the resultant $\vec{R}$ is the algebraic sum of all the scalar x-components.
9. The scalar y-components of the resultant are found in a similar way.
10. With the components known, the magnitude of the resultant is given by

$$R = \sqrt{R_x^2 + R_y^2}$$

11. In two dimension, the angle of the resultant with the x-axis can be found from the relation

$$\tan\theta = \frac{R_y}{R_x}$$

End of Chapter 1