Lecture One: Fundamental quantities in mechanics

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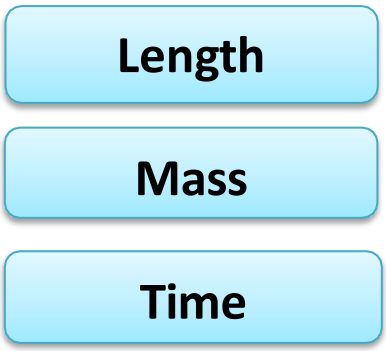
Fundamental quantities in mechanics

1.1 Physics and Measurements

PHYSICS is a science of measurement. The things which are measured are called **physical quantities** which are defined by the describing how they are to be measured. There are three fundamental quantities in mechanics:



All other physical quantities combinations of these three basic quantities. All physical quantities must have units attached to them.

- The base units for length, mass and time in these systems were as follows :

• In **CGS** system they were centimeter, gram and second respectively.

• In **FPS** system they were foot, pound and second respectively.

• In **MKS** system they were meter, kilogram and second respectively.

1.2 International System

The system of units which is at present internationally accepted for measurement is the Système Internationale d' Unites (French for International System of Units), abbreviated as **SI**. It is the modern metric system of measurement used throughout the world.

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SI base units

Table 1 gives the seven base quantities, assumed to be mutually independent, on which the SI is founded, and the names and symbols of their respective units, called "SI base units".

Table 1. SI Base Quantities and Units

Base quantity	Name	Symbol
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

SI derived units

Derived units are expressed algebraically in terms of base units or other derived units. The symbols for derived units are obtained by means of the mathematical operations of multiplication and division. For example, the derived unit for the derived quantity molar mass (mass divided by amount of substance) is the kilogram per mole, symbol kg/mol.

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Table 2. Examples of SI coherent derived units expressed in terms of SI base units.

quantity	symbol	unit
area	A	m^2
volume	V	m^3
density	D or ρ	$kg\ m^{-3}$
velocity	u or v	$m\ s^{-1}$
momentum	p	$kg\ m\ s^{-1}$
acceleration	a	$m\ s^{-2}$
force	F	$kg\ m\ s^{-2}$
work	W	$kg\ m^2\ s^{-2}$

Table 3.Prefix in SI System.

Multiple	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
0^{-15}	femto	f

1.3 Vectors and Scalars

Scalar quantity is one, which is fully defined by magnitude alone. Important scalars: distance, speed, mass, time, work, energy, power, etc.

Vector quantity is fully defined by magnitude and direction. Important vectors: displacement, velocity, acceleration, force, impulse, momentum, etc.

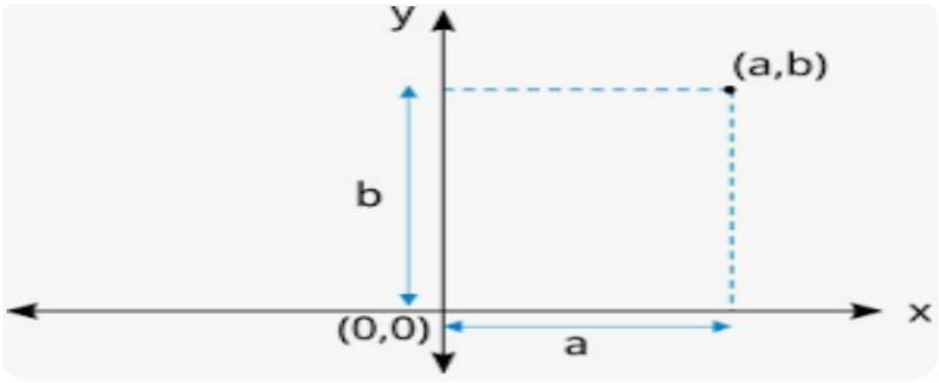
جميع الكميات الفيزيائية (اساسية او مشتقة) يمكن تقسيمها الى نوعين ، الاول الكمية القياسية Scalar والثانية الكمية المتجهة Vector .
الكمية القياسية يمكن تحديدها بمقدارها فقط مثل كتلة جسم 10Kg،بينما الكمية الاتجاهية تحتاج تحديد اتجاهها بالاضافة الى مقدارها مثل سرعة الرياح 12Km/h غربا.

1.4 Coordinate System

نحتاج في حياتنا العملية الى تحديد موقع جسم ما في الفراغ سواء كان ساكنا او متحركا،ولتحديد موقع ذلك الجسم نستعين بما يعرف باالحداثيات Coordinate وهنالك نوعان من االحداثيات التي سوف نستخدمها خلال دراسة الميكانيك لهذا الفصل.

1- Rectangular(Cartesian) Coordinate System

The distances are measured from two fixed perpendicular oriented lines (X-axis and Y-axis) measured in the same unit of length.

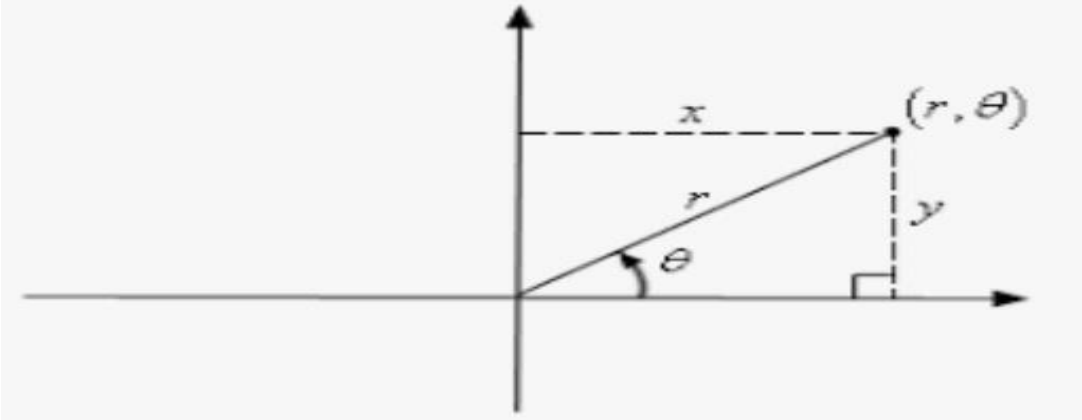


2- The polar Coordinate System

The polar coordinate system is a two-dimensional coordinate system in which the location of each point could be traced using two references:

1. Its distance from a reference line.

2. Its angle from a reference direction



- **The related between coordinate**

$$X = r \cos \Theta$$

$$Y = r \sin \Theta$$

$$r = \sqrt{X^2 + Y^2}$$

$$\tan \theta = \frac{X}{Y}$$

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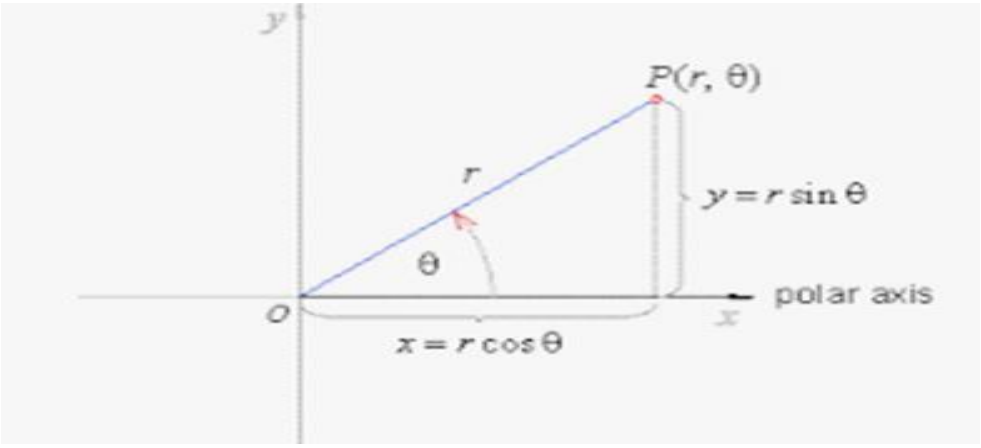


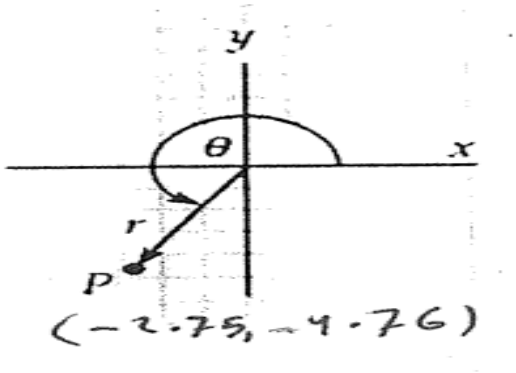
EXAMPLE:1

The polar coordinates of a point r =5.5m and Θ=240º what the Cartesian coordinates of this point?

Solve

$x = cos\theta = 5.5\ cos240^o = -2.75\ m$

$y = r\ sin\theta = 5.5 sin240^o = -4.76m$



H.W

1- The Cartesian coordinates of a point are $(-3, -\sqrt{3})$ what the polar coordinates?

2- The Cartesian coordinates of a point are (-3.5,-2.5) what the polar coordinates?

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3-Which one of the following is not a vector quantity:

A) velocity B) force C) energy D) momentum

4-Which of the following pairs are both scalar quantities?

A) Energy and force

B) Speed and mass

C) Temperature and velocity

D) Volume and weight

E) Density and acceleration