Phys. 101 Contents

Chapter 1

Units and Dimensions

Physical Quantities الكميات الفيزيائية

Basic اساسية

Length (m), Mass (kg),
Time (s)
Temperature (kelvin), K
Electric current (ampere), A
Luminous intensity (candela),
Amount of substance (mole).

Derived مشتقة

Area (m^2), Volume (m^3),
Velocity (m/s), Acceleration (m/s^2),
momentum (kg m/s), Force (N),
Work (J), ……

Dimensional Analysis

Some Units and Dimensions

Quantity	Length الطول	Mass الكتلة	Time الزمن
Units	m	kg	sec
Dimensions	L	M	T

Quantity	Equation	Units	Dimensions
Area (A) المساحة	Length × length	m^2	L^2
Volume (V) الحجم	Length × length × length	m^3	L^3
Velocity (v) السرعة	Distance/time	m/s	LT^{-1}
Momentum (p) الزخم الخطي	mass × velocity	kg m/s	MLT^{-1}
Acceleration (a) التسارع	Velocity/time	m/s^2	LT^{-2}
Force (F) القوة	mass × acceleration	$N = kg\ m/s^2$	MLT^{-2}
Work (W) or Energy الشغل والطاقة	Force × distance	$J = N.m = kg\ m^2/s^2$	ML^2T^{-2}
Pressure (P) الضغط	Force/Area	$Pa = N/m^2 = kg/(ms^2)$	$ML^{-1}T^{-2}$
Density (ρ) الكثافة	Mass / Volume	kg / m^3	ML^{-3}

Dimensional Analysis

It is a technique used to check the correctness of an equation or to assist in deriving an equation

Validation of the mathematical Physical equations requires that:

[L.H.S.] = [R.H.S.]

Example:

Ex. 1.1 page 8&9 in the book

Show that the expression $v = at$ is dimensionally correct. Where v is velocity, a is acceleration and t is time.

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Answer

$$[\text{L.H.S.}] = [v] = LT^{-1}$$

$$[\text{R.H.S.}] = [at] = LT^{-2}\ T = LT^{-2+1} = LT^{-1}$$

$\therefore [\text{L.H.S.}] = [\text{R.H.S.}]$ $\therefore$ **The expression is correct**

المعادلة صحيحة

Example:

Using the dimensional analysis, check the validity of the equation: $x = (\frac{1}{2})\ at^{2}$, where x is the distance, a is the acceleration and t is the time.

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Answer

[L.H.S.] = [x] = L

[R.H.S.] = [$(\frac{1}{2})\ at^{2}$] = $LT^{-2}\ T^{2} = LT^{0} = L$

$\therefore$ [L.H.S.] = [R.H.S.] $\therefore$ The equation is correct

Example

Ex. 1.2 page 9 in the book

Develop the precise form of the following expression:

$a = k\, r^n\, v^m$. **(here, a is acceleration, r is a circle radius and v is velocity)**

Answer

استنتج المعادلة التالية (اوجد مقدار m & n)

$$a = k\, r^n\, v^m$$

$$[\text{L.H.S.}] = [a] = LT^{-2}$$

$$[\text{R.H.S.}] = [k\, r^n\, v^m] = L^n (LT^{-1})^m = L^n L^m T^{-m} = L^{m+n} T^{-m}$$

$$[\text{L.H.S.}] = [\text{R.H.S.}]$$

$$\therefore LT^{-2} = L^{m+n} T^{-m} \qquad \therefore m = 2$$

$$m+n = 1 \qquad \therefore 2+n = 1 \qquad \therefore n = -2+1 \qquad \therefore n = -1$$

$$\therefore a = k\, v^2\, r^{-1} \qquad \therefore a = k\, v^2 / r$$

Example

Test the validity of the expression: $T = 2\pi\sqrt{\frac{L}{g}}$

(T: Time, L: length and g: acceleration due to gravity

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Answer

[L.H.S.] = [T] = T

[R.H.S.] = $\left[2\pi\sqrt{\frac{L}{g}}\right] = \sqrt{\frac{L}{LT^{-2}}} = \sqrt{T^2} = T$

$\therefore$ [L.H.S.] = [R.H.S.] $\therefore$ The equation is correct

1.3 Conversion of Units:

1 ft = 30.48 cm = 0.304 8 m

1 mile = 1 609 m = 1.609 km

1 m = 39.37 in. = 3.281 ft

1 in. = 2.54 cm = 0.025 4 m

$$15.0 \text{ in.} = (15.0 \cancel{\text{in.}})\left(\frac{2.54 \text{ cm}}{1 \cancel{\text{in.}}}\right) = 38.1 \text{ cm}$$

Homework: 12, 13