Topic: Physical Quantities and Units. Date:

Physical Quantities and Units.

* Any quantity that can be measured and has units is called a physical quantity.

* Physical Quantities are divided into 2 types.

1) Base Quantities.
2) Derived Quantities.

A Base quantity is one which cannot be expressed using other physical Quantities examples of Base quantities

Base quantities	Base units.
length	m
time	s
temperature	K / °C
mass	kg
amount of substance	mol
Current	A
light Intensity	cd (Candela)

* A derived quantity is one which can be expressed using one or more base quantities. Examples are

Topic: ____________ Date: ____________

Area	m^2
Volume	m^3
density	kgm^{-3}
speed	m/s
Acceleration	ms^{-2}
Force	N

Force Base units:

$F = ma$

$= kg \cdot ms^{-2}$ Base unit

$P = \frac{F}{A}$

$\frac{kgms^{-2}}{m^2} \Rightarrow kgm^{-1}s^{-2}$

Workdone

$W = F \times d$

$kgms^{-2} \times m$ kgm^2s^{-2}

Power

$P = \frac{Wd}{t} = \frac{kgm^2s^{-2}}{s} = kgm^2s^{-3}$

Topic: ______ Date: ______

Energy = J
WD = J]

* Energy will have same base units as w.done.

Charge

$Q = It$

$A \cdot s \Rightarrow \boxed{As}$

Q = Charge
I = current.
t = time.

Voltage

$$\text{Voltage} = \frac{WD}{Q}$$

$$= \frac{kg\,m^2 s^{-2}}{As}$$

$$\boxed{kg\,A^{-1} m^2 s^{-3}}$$

Resistance

$$\text{Resistance} = \frac{V}{I}$$

$$\frac{kg\,A^{-1} m^2 s^{-3}}{A} \Rightarrow \boxed{kg\,m^2 A^{-2} s^{-3}}$$

Specific heat Capacity

$Q = mc\Delta\theta$

$$c = \frac{Q}{m \cdot \Delta T} = \frac{kg\,m^2 s^{-2}}{kg \cdot K} = m^2 s^{-2} K^{-1}$$

Topic: ____________ Date: ____________

Specific Latent Heat

$Q = ml$

$l = \frac{Q}{m} = \frac{kg\,m^2 s^{-2}}{kg}$ $\boxed{m^2 s^{-2}}$

Q) $F = \frac{Q^2}{4\pi x r^2}$ $F = \frac{y I^2}{2\pi \cdot d}$

Write down base units of $\frac{1}{xy}$?

F = force
Q = charge
I = current
d = distance
r = radius

Equate:

$$\frac{Q^2}{4\pi x r^2} = \frac{y \cdot I^2}{2\pi \cdot d}$$

$$\frac{1}{xy} = \frac{I^2\ 4\pi\ r^2}{2\pi \cdot d \times Q^2}$$

$$= \frac{2 \times r^2 \times I^2}{Q^2 \times d}$$

Remember constants have no units hence such quantities are called dimensionless quantities.

$$= \frac{2 \times m^2 \times A^2}{(As)^2 \times m} \Rightarrow \boxed{m\ s^{-2}}$$

Topic: ____________ Date: ____________

Q) Which quantity is denoted by $\frac{1}{xy}$

Ans) Acceleration.

Q2) In the given equation $x = k \cdot r^3 (P_1 - P_2) \cdot \sqrt{\frac{M}{R \cdot T}}$

Find the base units of x

given that

r = radius

P = Pressure

T = temperature

k = dimensionless quantity

M = mass per mole

R = $J\,K^{-1}\,mol^{-1}$

$$x = k \cdot r^3 (P_1 - P_2) \cdot \sqrt{\frac{M}{R \cdot T}}$$

$$= m^3 \left(kg\,m^{-1}s^{-2}\right) \sqrt{\frac{kg\,mol^{-1}}{kg\,m^2 s^{-2} K^{-1} mol^{-1} (K)}}$$

($m^3 \to r^3$, $kg\,m^{-1}s^{-2} \to P_1 - P_2$, $kg\,mol^{-1} \to M$, $kg\,m^2 s^{-2} K^{-1} mol^{-1} \to R$, $(K) \to T$)

$$kg\,m^2 s^{-2} \sqrt{\frac{1}{m^2 s^{-2}}} \Rightarrow \frac{kg\,m^2 s^{-2}}{m\,s^{-1}} = kg\,m\,s^{-1}$$

Topic: ____________ Date: ____________

Homoginity of Physical Equation

An Equation is said to be homogenous if base units on LHS are identical to the base units on RHS.

(for eg)

For any equation to be classified as a correct Equation, it must satisfy the test of homogenity.

1) $d = s \times t$

$m = (ms^{-1})(s)$

$m = m$ [hence homogenous]

2) $v = f\lambda$

$ms^{-1} = s^{-1}\ m$

$ms^{-1} = ms^{-1}$ [hence homogenous]

3) $P = \rho g h$

$kg\,m^{-1}s^{-2} = kg\,m^{-3} \times ms^{-2} \times m$

$= kg\,m^{-1}s^{-2}$

[hence homogenous]

4) $v = u + at$

→ If an equation contains more then one term on any one side, then for homogenity firstly breakdown the equation.

* Compare v with u

$ms^{-1} = ms^{-1}$

* Compare v with at

$ms^{-1} = ms^{-2}(s)$

$ms^{-1} = ms^{-1}$

Hence now equation can be classified as correct equation.

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Topic: ______ Date: ______

Hence now the eq can be classified as correct or Homogeneous, Eq.

Q) In the following examples suggest which eq can be classified as correct/Homogenous equation?

i) $E = mv$

ii) $v = fg$

iii) $E = \frac{1}{2} f v^3$

iv) $v = \sqrt{g\lambda}$

E = Energy
m = mass
v = velocity
f = frequency
g = acceleration of free fall
f = frequency
λ = Wave length.

Solution.

i) $E = mv$

$kg\,m^2 s^{-2} = (kg)(ms^{-1})$

Not Homogenous

ii) $v = fg$

$ms^{-1} = (s^{-1})(ms^{-2})$

$ms^{-1} = ms^{-3}$

Not Homogenous

iii) $E = \frac{1}{2} f v^3$

$kg\,m^2 s^{-2} = s^{-1} (ms^{-1})^3$

$kg\,m^2 s^{-2} = s^{-1} m^3 s^{-3}$

$= s^{-4} m^3$

Not Homogenous

iv) $v = \sqrt{g\lambda}$

$(ms^{-1})^2 = (\sqrt{ms^{-2}\,m})^2$

$m^2 s^{-2} = m^2 s^{-2}$

Homogenous ☺

Topic: ______ Date: ______

Q) Given that the eq shown below is homogenous use this information to find the base unit of P and Q.

$$3\left(L + \frac{a^2}{P}\right) = Q\,T^2 \sin\theta$$

L = length a = radius T = time.

Q) Given that the eq shown below is homogenous use this information to find the base unit of P and Q.

$$3\left(L + \frac{a^2}{P}\right) = Q\,T^2 \sin\theta$$

$$3L + \frac{3a^2}{P} = Q\,T^2 \sin\theta$$

$$3L = Q\,T^2 \sin\theta$$

$$\frac{m}{s^2} = Q$$

$$\boxed{Q = m s^{-1}}$$

$$\frac{3a^2}{P} = Q\,T^2 \sin\theta$$

⇓ Ignore no units.

$$\frac{a^2}{Q\,T^2} = P \Rightarrow \frac{m^2}{m s^{-1} \times s^2} = \boxed{m}$$

Topic: ______ Date: ______

⇒ How to find unknown constants x, y, z etc in a Homogenous equation.

In the given eq find values of x, y & z given that equation is Homogenous.

$$V = \lambda^x P^y \rho^z$$

V = velocity

P = Pressure

ρ = density.

λ = wave length.

Topic: ______ Date: ______

⇒ How to find unknown constants x, y, z etc in a Homogenous equation.

In the given eq find values of x, y & z given that equation is Homogenous.

$$V = \lambda^{x} P^{y} \rho^{z}$$

V = velocity
P = Pressure
ρ = density.
λ = wave length.

$$ms^{-1} = m^{x}(kgm^{-1}s^{-2})^{y}(kgm^{-3})^{z}$$

i) Compare (m) from both sides.

$$m^{1} = m^{x}(m^{-1})^{y}(m^{-3})^{z}$$

Use Indices.

$$1 = x - y - 3z \quad \text{--- (1)}$$

ii) Compare s

$$s^{-1} = (s^{-2})^{y}$$

Use Indices.

$$-1 = -2y$$

$$\frac{-1}{-2} = y$$

$$\boxed{\frac{1}{2} = y}$$

iii) Compare kg

$$kg^{0} = kg^{y}\, kg^{z}$$

$$0 = y + z$$

$$z = -y$$

$$\boxed{z = -\frac{1}{2}}$$

For x.

$$x = 1 + y + 3z$$

$$x = 1 + \frac{1}{2} + 3\left(\frac{-1}{2}\right)$$

$$x = \frac{3}{2} - \frac{3}{2}$$

$$\boxed{x = 0}$$

Topic: ______ Date: ______

Question: $T = L^x g^y$

T = time
L = length
g = Acc due to gravity.

Question: $T = L^x g^y$

T = time
L = length
g = Acc due to gravity.

$(s) = m^x (ms^{-2})^y$

Compare powers of s

$1 = -2y$

$y = \frac{-1}{2}$

Compare powers of m

$0 = x + y$

$x = \frac{1}{2}$

$0 = x - \frac{1}{2}$

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Topic: ____________ Date: ____________

Question:

$F = 6\pi r n v$

F = Force

r = radius

v = velocity

i) Find Base unit of n.

ii) $\frac{V}{t} = (L)^x \left(\frac{P}{r}\right)^y (n)^z$

Using your answer in Part (i) find x y and z

V = Volume t = time L = length r = radius P = Pressure

Question:

$F = 6\pi r n v$

F = Force

r = radius

v = velocity

i)

$kg\,m\,s^{-2} = m\,(n)\,(m s^{-1})$

$\frac{kg\,m\,s^{-2}}{m^2\,s^{-1}} = n$

$kg\,m^{-1}\,s^{-1} = n$

Topic: ______ Date: ______

ii) $\frac{V}{t} = (L)\left(\frac{P}{r}\right)^{y}(n)$

Using your answer in Part (i) find x y and z

V = Volume t = time L = length r = radius P = Pressure

$$\frac{m^3}{s} = (m)^x \left(\frac{kg\,m^{-1}s^{-2}}{m}\right)^y \left(kg\,m^{-1}s^{-2}\right)^z$$

$$m^3 s^{-1} = m^x \left(kg\,m^{-2}s^{-2}\right)^y \left(kg\,m^{-1}s^{-1}\right)^z$$

i) Compare "s"

$-1 = -2y - z$ ——— (1)

ii) Compare "kg"

$0 = y + z$ ——— (2)

iii) Compare "m"

$3 = x - 2y - z$ ——— (3)

$z = -y$

$-1 = -2y - (-y)$

$-1 = -2y + y \Rightarrow -1 = -y$ $\boxed{y = 1}$ $\boxed{z = -1}$ $\boxed{x = 4}$

Topic: ______ Date: ______

Question

$I = S q n v^x$

Find x :

I = current

S = Area

q = charge

v = velocity

n = no of electrons per unit Volume

Question

$I = S q n v^x$

Find x :

I = current

S = Area

q = charge

v = velocity

n = no of electrons per unit Volume

$I = A \quad S = m^2 \quad q = As \quad n = \frac{1}{m^3}$

$v = ms^{-1}$

$\frac{\text{number of electron}}{\text{Volume}} = \frac{1}{m^3}$

$A = (m^2)(As)(m^{-3})(ms^{-1})^x$

Concept

no of cows
no of apples
no of People

} No units

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Topic: Date:

⇒ Compare "m"

$0 = 2 - 3 + x$

$x = -2+3$

$\boxed{x = 1}$

Lets compare "s"

$0 = 1 - x$

$\boxed{x = 1}$

Topic: ______ Date: ______

⇒ Guys Must learn this by Next class

- Mass of an Apple = 200g to 400g
- Number of joules in 1 kwh = 1000W × 3600s = 3.6×10^6J
- Wavelength of Red light = 700nm

  Wave length of Green light = 500nm

  Wavelength of Violet light = 400nm
- Pressure due to 10m of water = pgh = (1000)(10)(10) = 10^5 Pa
- Speed of sound in Air = 300m/s to 330m/s
- Density of Air = 1.4kg/m^3
- Mass of a protector = 20g to 50g
- Volume of an adults head (assume sphere apply 4/3×pi×r^3 taking r》 8cr
- Freq of audible sound = 20Hz to 20,000 Hz
- Wavelength of Ultraviolet = 10nm to 400nm
- Mass of 30cm plastic ruler = 30g to 100g
- Size (diameter) of a nucleus = 10^-13m to 10^-15m
- Size (diameter) of an atom = 10^-9m to 10^-11m
- Mass of a person = 70kg
- Height of a person = 1.5m
- Walking Speed of a person = 1.5m/s
- Speed of Car on motorway = 30m/s
- Volume of a can of drink = 300cm^3
- Density of water = 1000kg/m^3
- Density of Mercury = 13600kg/m^3
- Typical current in domestic appliance = 13A
- emf of a Car battery = 12V
- Average K.Energy of an athlete during a 100m race = 4000J
- Temperature of a hot oven = 800°C

Topic: ______________ Date: ______________

Prefix	Power of 10	Symbol
pico	10^{-12}	p
nano	10^{-9}	n
micro	10^{-6}	μ
milli	10^{-3}	m
centi	10^{-2}	c
deci	10^{-1}	d
deka	10^{1}	da
hecto	10^{2}	h
kilo	10^{3}	k
mega	10^{6}	M
giga	10^{9}	G
tera	10^{12}	T

Topic: ____________ Date: ____________

4) The momentum of an object of mass m is p. where p

Which quantity has the same base units as $\frac{p^2}{m}$?

A energy

B force

C power

D velocity

9) Which of the following definitions is correct and uses only quantities rather than units?

A Density is mass per cubic metre.

B Potential difference is energy per unit current.

C Pressure is force per unit area.

D Speed is distance travelled per second.

10) When a beam of light is incident on a surface, it delivers energy to the surface. The intensity of the beam is defined as the energy delivered per unit area per unit time.

What is the unit of intensity, expressed in SI base units?

A $kg\,m^{-2}\,s^{-1}$ B $kg\,m^{2}\,s^{-3}$ C $kg\,s^{-2}$ D $kg\,s^{-3}$

Date:

12) A metal sphere of radius r is dropped into a tank of water. As it sinks at speed v, it experiences a drag force F given by $F = krv$, where k is a constant.

What are the SI base units of k?

A $kg\,m^{2}\,s^{-1}$ B $kg\,m^{-2}\,s^{-2}$ C $kg\,m^{-1}\,s^{-1}$ D $kg\,m\,s^{-2}$

Date:

19) In the expressions below

a is acceleration,
F is force,
m is mass,
t is time,
v is velocity.

Which expression represents energy?

A Ft

B Fvt

C $\frac{2mv}{t}$

D $\frac{at^2}{2}$

20) Which in...

Topic: ______________________ Date: ______________________

Topic: ____________________ Date: ____________________

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