Units & measurements

Q-1) What is a unit?

> Unit is a standard used for the measurement of a physical quantity. It should be:

* convinient to use
* not changing with respect to space & time
* universally accepted
* easily reproducible.

prefix	Symbol of prefix	multiplying factor
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

Q-2) Base units.

Length = metre m
mass = kilogram kg
time = seconds s
temperature = kelvin K
electric current = ampere A
amount of a subst = mole mol

luminous intensity = candela cd

πrad = 180°

2D Plane angle = radian rad — 2πrad max angle

3D Solid angle = steradian sr — 4πrad

Q-3) Derived units.

* speed/velocity = $\frac{D}{t} = \frac{m}{s} = ms^{-1}$

* force = m × a = kg × $\frac{m}{s^2}$ = $kgms^{-2}$

* work done/energy = f × d = $kgms^{-2} \times m = kgm^2s^{-2}$

* pressure = $\frac{f}{a} = \frac{kgms^{-2}}{m^2} = kgm^{-1}s^{-2}$

* density = $\frac{m}{V} = \frac{kg}{m3} = kgm^{-3}$

* frequency = $\frac{1}{t} = \frac{1}{s} = s^{-1}$

* potential difference (voltage) = $\frac{\text{work done}}{\text{charge}} = \frac{kgm^2s^{-2}}{As} = kgm^2s^{-3}A^{-1}$

* charge = I × t = A × s = As

Q-4) Homogenity of an equation?

> If an equation has the same units on both sides, they cancel each other out ∴ the equation is homogenious.

eg: ~~V = I R~~ CF = $\frac{mv^2}{r}$

~~V = I R~~

LHS = CF = $kgms^{-2}$

RHS = $\frac{kgm^2s^{-2}}{m} = kgms^{-2}$

RHS = LHS ∴ equation is homogenious

s = displacement
a = acceleration
t = time
u = initial velocity
v = final velocity.

Q-5) Estimating masses

mass of an orange = 100 - 150 g
mass of an adult human = 60 - 80 kg
height of a room = 2 - 3 m
diameter of a pencil = 0.5 - 1 cm
volume of a small beam = $0.5\ cm^3$
volume of a human head = $4 \times 10^{-3}\ m^3$
speed of a jet plane = 220 m/s
Temperature of human body (Kelvin) = 310 K
Frequency of audible sound. = 20 - 22 Hz
wavelength of UV radiation (nm) = 400 nm
mass of plastic ruler (30 cm) = 70 - 75 g
Density of air at atmospheric pressure = $1.2\ kg/m^3$
thickness of a sheet of paper. = 0.1 mm
time for sound to travel 100 m in air = 0.3 seconds
weight of 1000 cc water. = 10 N
mass of an apple. = 130 g
pressure due to depth of 10 m of water. = $10^5\ N/m$ ($p = hgd$)
diameter of atom = $3 \times 10^{-10}\ m$
diameter of nucleus = $3 \times 10^{-15}\ m$
diameter of a strand of hair = $3 \times 10^{-4}\ m$

Q-6) Measuring instruments

Vernier callipers LC = 0.01 cm

MSR → VSR → VSR × LC → MSR + (VSR × LC)
(main scale reading; vernier scale reading; least count; Total reading.)

Micrometer screw gauge LC = 0.001 cm

MSR → CSR → (MSR + CSR) × LC → Total reading ± error.
(Total reading; corrected total reading.)

Q-7) What is the true value.

> Actual value / value of the most accurate measurement. Mean value is taken as the true value.

Q-8) What is accuracy and precision?

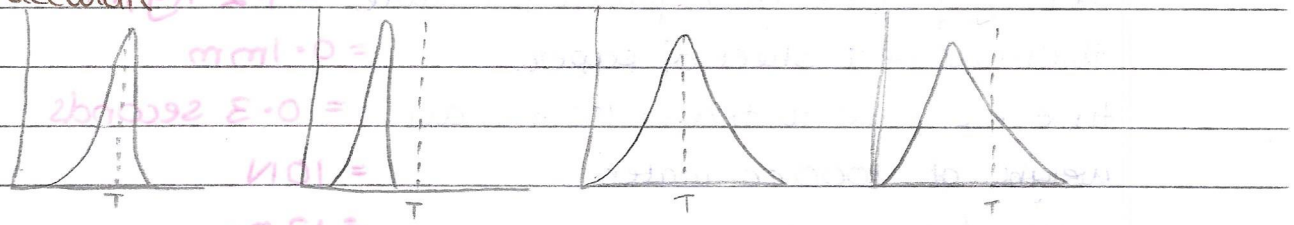
> Accuracy is the degree of closeness to the true value. Greater accuracy means less error.

> Precision is the degree of exactness to which a quantity is measured.

↳ It depends on the measuring instrument.

↳ Precision of an instrument is the smallest non-zero reading that can be measured using the instrument.

precise & accurate | precise | accurate | neither



Q-9) What is range of readings?

> It's the difference between the smallest and largest value of measurements.

Q-10) What is error?

> Error is the difference between the measurement and the true value.

Random error	Systematic error
* readings are scattered on both sides of true value	* readings are on one side of the true value.
* reduced by averaging	* can't be reduced
* occur unpredictably	* occur systematically
* human error	* error in equipment
eg: reading a scale from different angles.	eg: wrongly calibrated scale

Q-11) What is uncertainity?

> The total range of values in which a measurement is likely to be. It's expressed as ± attached to true value.
(The range of spread of readings)

Absolute uncertainity

eg: 2.52 ± 0.01

Relative uncertainity

eg: $\frac{0.01}{2.52}$ = $\frac{\text{absolute uncertainity}}{\text{true value.}}$

Percentage uncertainity (%)

eg: $\frac{0.01}{2.52} \times 100$ = relative uncertainity $\times 100$.

eg: $A = lb$

$\frac{\Delta A}{A} = \frac{\Delta L}{L} + \frac{\Delta b}{b}$ always add.

[* addition * subtraction
add absolute
* multiplication * division
use %]

eg: $z = x^n$

$\frac{\Delta z}{z} = n\left[\frac{\Delta x}{x}\right]$

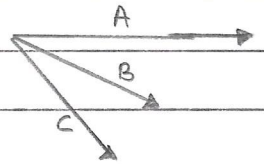
Q-12) Scalar and vector quantities.

Scalar	Vectors
* have magnitude (size)	* have magnitude and direction
* represented by no. + unit	* no., unit + direction
* not represented graphically	* graphically by a line in direction.
* added by simple math.	* using law of vectors.
eg: mass, volume, speed	eg: displacement, velocity, force.

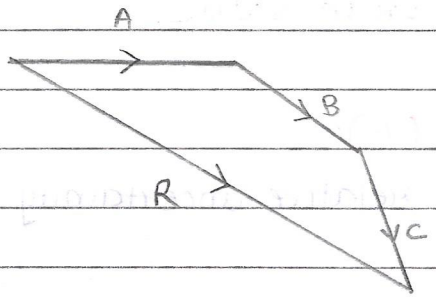
Adding vectors

* If 2 or more vectors are represented in magnitude and direction by sides of a polygon, the resultant force is represented by the closing side of the polygon in opposite direction.

eg:



① draw the 1st arrow in same size and direction. Then from end of that arrow draw start of next arrow.



② R = resultant force.