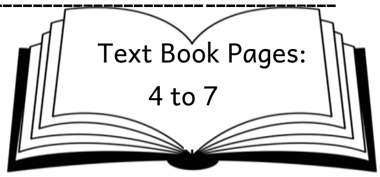
Standard units in Physics



Physical quantities

- ✓ A physical quantity is a physical property that can be measured quantitatively (in numbers).

  Eg: mass, pressure, density, temperature and forces

- ✓ Measurement of any physical quantity involves comparison with a certain basic internationally accepted reference standard called unit. The result of a measurement of a physical quantity is expressed by a **number** (or numerical measure) accompanied by a **unit**.

Example: Distance = 25m

Physical Quantity *Magnitude (size)* *Unit*

- ✓ Physical quantities are classified as either *Base quantities (fundamental quantity)* or *Derived quantities.*

Base quantities

- ✓ The starting quantities of any system are known as base quantities and they cannot be expressed in terms of other physical quantities.
- ✓ Units of **Base quantities** are called **Base units or SI units.**
- ✓ There are **seven** base quantities.

Base Quantity	Unit name	Unit symbol
mass	kilogram	Kg
time	second	s
length	metre	m
temperature	kelvin	K
electric current	ampere	A
amount of substance	mole	mol
light intensity	candela	cd

- ✓ To deal with the Advanced Level physics tests, you only need to memorize the six highlighted base quantities and units.
- ✓ When scientists do research, they must communicate the results of their experiments with each other and agree on a system of units for their measurements.
- ✓ This system of units is called the International System of Units (French: System International d'unités, SI). ie, SI Units.
- ✓ If the physical quantity is not in SI unit, it can be converted to SI unit.

Derived Quantities

- ✓ Physical quantities other than the base quantities are called derived quantities.
- ✓ Derived quantities are obtained from a combination of various base quantities.

$$\underbrace{speed}_{ms^{-1}} = \frac{\overbrace{distance}^{m}}{\underbrace{time}_{s}}$$

Speeds are typically expressed in units of meters per second ***m/s*** *which will now be written as* ***ms⁻¹***

- ✓ Some derived units may be given specific name such as ***newton*** (***Force***) and ***joule*** (***Work***).
- ✓ Derived quantity units can be worked out using defining word equations.

Derived Quantity	derived unit name (symbol)	Defining word equation	base unit equivalents	other unit
acceleration	-	$acceleration = \frac{velocity}{time} = \frac{ms^{-1}}{s}$	ms^{-2}	-
area	-	$area = length \times length = m \times m$	m^2	-
volume	-	$area = length \times length \times length = m \times m \times m$	m^3	-
density	-	$density = \frac{mass}{volume} = \frac{kg}{m^3}$	kgm^{-3}	
pressure	pascal (pa)	$pressure = \frac{force}{area} = \frac{mass \times acceleration}{area} = \frac{kg\cancel{m}s^{-2}}{m^{\cancel{2}-1}}$	$kgm^{-1}s^{-2}$	$N\,m^{-2}$
momentum	-	$momentum = mass \times velocity = kg \times ms^{-1}$	$kgms^{-1}$	
force, weight	newton (N)	$force = mass \times acceleration = kg \times ms^{-2}$	$kgms^{-2}$	-
moments	-	$moments = force \times distance = kgms^{-2} \times m$	kgm^2s^{-2}	$N\,m$
energy / work done	joule (J)	$work\ done = force \times distance = kgms^{-2} \times m$	kgm^2s^{-2}	$N\,m$
power	watt (W)	$power = \frac{work\ done}{time} = \frac{kgm^2s^{-2}}{s}$	kgm^2s^{-3}	$J\,s^{-1}$
frequency	hertz (Hz)	$frequency = \frac{1}{time} = \frac{1}{s}$	s^{-1}	-
electric charge	coulomb (C)	$charge = current \times time = A \times s$	$A\,s$	-
voltage / emf	volt (V)	$voltage = \frac{energy}{charge} = \frac{kgm^2s^{-2}}{As}$	$kgm^2s^{-3}A^{-1}$	$J\,C^{-1}$
resistance	ohm (Ω)	$resistance = \frac{voltage}{current} = \frac{kgm^2s^{-3}A^{-1}}{A}$	$kgm^2s^{-3}A^{-2}$	$V\,A^{-1}$

Power prefixes

✓ Power Prefixes are used for multiples or sub multiples of the units.
This is to avoid too many zeroes which may give rise to human error.

factor	prefix	symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-2}	centi	c
10^{-3}	milli	M
10^{-6}	micro	µ
10^{-9}	nano	n
10^{-12}	pico	p

Significant Figures

(digits in a number that are reliable and absolutely necessary to indicate the quantity of that number)

✓ All the non-zero digits are significant.
Eg: 98765 has 5 significant figures

✓ Zeros between two non-zero digits are significant
Eg: 120586 has 6 significant figures

✓ **Zeros** that come **before** all non-zero digits are **not** significant
Eg: 0.002308 has 4 significant figures

✓ Zeros after non-zero digits within a number without decimals are **not** significant
Eg: 123000 has 3 significant figures

✓ Zeros after non-zero digits within a number with decimals are significant
The terminal zero(s) in a number with a decimal point are significant.
Eg: 3.500 has 4 significant figures
0.06900 has 4 significant figures
689.0023 **has 7 significant figures**

Order of magnitude *(Scientific Notation / Standard form / Exponential form)*

- ✓ An estimate of *size* or *magnitude* expressed as a *power of ten.*
- ✓ In this notation, every number is expressed as **$a \times 10^b$,**
  where **a** is a number between 1 and 10, and **b** is any positive or negative power of 10.
- ✓ In this method, the decimal is written after the first digit,
  - ➢ The diameter of the Earth is 1.28×10^{7}m
  - ➢ The diameter of Hydrogen atom is 1.06×10^{-10} m

Working with indices

Exponent Rules For $a \neq 0, b \neq 0$	
Product Rule	$a^x \times a^y = a^{x+y}$
Quotient Rule	$a^x \div a^y = a^{x-y}$
Power Rule	$\left(a^x\right)^y = a^{xy}$
Power of a Product Rule	$\left(ab\right)^x = a^x b^x$
Power of a Fraction Rule	$\left(\frac{a}{b}\right)^x = \frac{a^x}{b^x}$
Zero Exponent	$a^0 = 1$
Negative Exponent	$a^{-x} = \frac{1}{a^x}$
Fractional Exponent	$a^{\frac{x}{y}} = \sqrt[y]{a^x}$

Practice Questions:

1. Which of these units is the same as the newton?
   A. kg m s^{-1} B. kg m s^{-2} C. kg m^2 s^{-2} D. kg m^2 s^{-3}

2. Which of the following is not a SI base quantity?
   A. force B. length C. mass D. time

3. Which of the following units could be used for power?
   A. kg m s^{-2} B. kg m^2 s^{-2} C. kg m^2 s^{-3} D. kg^2 m^2 s^{-3}

4. Which of the following is not a unit of energy?
   A. N s^{-1} B. kW h C. N m D. W s

5. Which of the following is a unit equivalent to the pascal?
   A. kg m s^{-1} B. kg m s^{-2} C. kg m^{-1} s^{-2} D. kg m^{-2} s^{-2}

6. Which of these quantities is not measured in an SI base unit?
   A. Distance B. force C. mass D. time

7. Which of the following is a derived SI unit?
   A. joule B. metre C. power D. time

8. Which of the following is a derived SI quantity?
   A. force B. length C. second D. watt

9. Which of the following is a correct statement?
   A. Weight is a base quantity. B. Velocity is a base quantity.
   C. Mass is a derived quantity. D. Force is a derived quantity.

10. Which of the following is equivalent to the joule in terms of SI base units?
   A. kg m^2 s^{-3} B. kg m^2 s^{-2} C. kg m s^{-2} D. kg m s^{-1}

11. Select the row of the table that shows the correct SI base units for force and work done.

	Force	Work done
A.	kg m^2 s^{-2}	kg m^3 s^{-2}
B.	kg m s^{-2}	kg m^2 s^{-2}
C.	kg m^2 s^{-2}	kg m s^{-2}
D.	kg m s^{-2}	kg m^3 s^{-2}

12. Which of the following SI units can only be used with a scalar quantity?
   A. m B. s C. m s^{-1} D. m s^{-2}

13. Which of the following is the unit of upthrust?
   A. N m^{-2} B. N m^{-1} C. N m D. N

14. Which of the following SI units is only used with a vector quantity?
   A. s B. m^3 C. ms^{-1} D. ms^{-2}

15. The unit for power is the watt. Which of the following is equivalent to the watt?
   A. Kg m s^{-2} B. kg m^2 s^{-2} C. kg m s^{-3} D. kg m^2 s^{-3}

16. The newton can be written in base units as
   A. kg m B. kg m s^{-1} C. kg m s^{-2} D . kg m^2s^{-2}

17. Which of the following quantities could have units of N m s^{-1}?
   A. gravitational field strength B. gravitational potential energy
   C. Power D. work done