AL- Mustaqpal University

Science College

Dep. Biochemistry

First Stage

Biophysics

Lec 2

Use of Correct Physical Units

with numerical magnitudes, unit conversion skills, Scientific unit systems and unit types

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The range of objects and phenomena studied in physics is immense. From the incredibly short lifetime of a nucleus to the age of the Earth, from the tiny sizes of sub-nuclear particles to the vast distance to the edges of the known universe, from the force exerted by a jumping flea to the force between Earth and the Sun, there are enough factors of 10 to challenge the imagination of even the most experienced scientist. Giving numerical values for physical quantities and equations for physical principles allows us to understand nature much more deeply than does qualitative description alone. To comprehend these vast ranges, we must also have accepted units in which to express them. And we shall find that (even in the potentially mundane discussion of meters, kilograms, and seconds) a profound simplicity of nature appears—all physical quantities can be expressed as combinations of only four fundamental physical quantities: length, mass, time, and electric current.

We define a physical quantity either by specifying how it is measured or by stating how it is calculated from other measurements. For example, we define distance and time by specifying methods for measuring them, whereas we define average speed by stating that it is calculated as distance traveled divided by time of travel.

Measurements of physical quantities are expressed in terms of *units*, which are standardized values. For example, the length of a race, which is a physical quantity, can be expressed in units of meters (for sprinters) or kilometers (for distance runners). Without standardized units, it would be extremely difficult for scientists to express and compare measured values in a meaningful way.

There are two major systems of units used in the world: *SI units* (also known as the metric system) and *English units* (also known as the customary or imperial system). **English units** were historically used in nations once ruled by the British Empire and are still widely used in the United States. Virtually every other country in the world now uses SI units as the standard; the metric system is also the standard system agreed upon by scientists and mathematicians. The acronym "**SI**" is derived from the French ***Système International***.

SI Units: Fundamental and Derived Units

Table 1 gives the fundamental SI units that are used throughout this textbook. This text uses non-SI units in a few applications where they are in very common use, such as the measurement of blood pressure in millimeters of mercury (mm Hg). Whenever non-SI units are discussed, they will be tied to SI units through conversions.

It is an intriguing fact that some physical quantities are more fundamental than others and that the most fundamental physical quantities can be defined only in terms of the procedure used to measure them. The units in which they are measured are thus called fundamental units. the fundamental physical quantities are taken to be length, mass, time, and electric current. All other physical quantities, such as force and electric charge, can be expressed as algebraic combinations of length, mass, time, and current (for example, speed is length divided by time); these units are called derived units.

Length	**Mass**	**Time**	**Electric Current**
meter (m)	kilogram (kg)	second (s)	ampere (A)

SI units are part of the metric system. The metric system is convenient for scientific and engineering calculations because the units are categorized by factors of 10. Table 2 gives metric prefixes and symbols used to denote various factors of 10.

Prefix	Symbol	Value	
exa	E	10^{18}	exameter
peta	P	10^{15}	Peta meter
tera	T	10^{12}	terameter
giga	G	10^{9}	gigameter
mega	M	10^{6}	Mega meter
kilo	k	10^{3}	kilometer
hecto	h	10^{2}	hectometer
deka	da	10^{1}	dekameter
—	—	10^{0} (=1)	
deci	d	10^{-1}	decimeter
centi	c	10^{-2}	centimeter
milli	m	10^{-3}	millimeter
micro	µ	10^{-6}	micrometer
nano	n	10^{-9}	nanometer
pico	p	10^{-12}	picometer
femto	f	10^{-15}	femtometer
atto	a	10^{-18}	attometer

Unit Conversion and Dimensional Analysis

It is often necessary to convert from one type of unit to another. For example, if you are reading a European cookbook, some quantities may be expressed in units of liters and you need to convert them to cups. Or, perhaps you are reading walking directions from one location to another and you are interested in how many miles you will be walking. In this case, you will need to convert units of feet to miles.

Let us consider a simple example of how to convert units. Let us say that we want to convert 80 meters (m) to kilometers (km).

The first thing to do is to list the units that you have and the units that you want to convert to. In this case, we have units in meters and we want to convert to kilometers.

Next, we need to determine a conversion factor relating meters to kilometers. A conversion factor is a ratio expressing how many of one unit are equal to another unit. 100 centimeters in 1 meter, 60 seconds in 1 minute, and so on. In this case, we know that there are 1,000 meters in 1 kilometer.

Now we can set up our unit conversion. We will write the units that we have and then multiply them by the conversion factor so that the units cancel out, as shown:

$$\frac{80}{1000} = 0.08 \text{ Km}$$

Quantity	Name	Symbol
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	a
Temperature	Kelvin	k
Amount of substance	Mole	mol
Luminous intensity	Candela	cd

Derived Units

A derived unit is a unit that results from a mathematical combination of SI base units. Calculations involving derived units follow the same principles.

SI Derived Units:

- There are only limited derived units that form different operations over the base units. In the case of derived units, the dimensions are expressed related to the dimensions of the base units. It can also be expressed by combining base and derived units.

The Derived SI Units are as follows:

Hertz for Frequency

Joule for Energy, Work, Heat

Pascal for Pressure, Stress

Radian for Angle

Coulomb for Electric Charge

Newton for Force

Ohm for Electric Resistance

Volt for Voltage

Farad for Electrical Capacitance

Siemens for Electrical Conductance

Tesla for Magnetic Induction

Henry for Electrical Inductance

Degree Celsius for Temperature relative to degree Kelvin

Weber for Magnetic

As you can see, the Derived SI Units and the quantities they represent are connected to or based on the seven Base SI Units. Together, the seven Base SI Units plus the

Derived SI Units form the collective International System of Units. This system of units is used all over the world in scientific research and study. Most of these units are also used in most of the world for regular, day-to-day use. For example, most countries in the world use the metre and kilometre as measures of distance and length, while only a few countries use miles as the main measurement of distance and length.

Discussion

1. What is the fundamental SI unit for measuring length?

A. Kilogram

B. Meter

C. Second

D. Ampere

E. Mole

Answer: B. Meter

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2. Which of the following is NOT an SI base unit?

A. Kelvin

B. Pascal

C. Kilogram

D. Ampere

E. Mole

Answer: B. Pascal

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3. The metric system is based on which factor?

A. Powers of 2
B. Powers of 5
C. Factors of 10
D. Random increments
E. Arbitrary numbers
Answer: C. Factors of 10

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4. The SI unit for electric current is:

A. Volt

B. Ohm

C. Ampere

D. Watt

E. Coulomb

Answer: C. Ampere

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5. What is the prefix for 10^{-3} ?

A. Micro
B. Milli
C. Centi
D. Nano
E. Pico
Answer: B. Milli

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6. Derived units are:

A. Fundamental SI units used directly

B. Units expressed through combinations of base SI units

C. Only used in English units

D. Specific to temperature

E. Irrelevant in modern physics

Answer: B. Units expressed through combinations of base SI units

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7. What does the prefix "giga-" represent?

A. 10^3

B. 10^6

C. 10^9

D. 10^{12}

E. 10^{-3}

Answer: C. 10^9

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8. A force is measured in which derived SI unit?

A. Joule
B. Newton
C. Watt
D. Pascal
E. Henry
Answer: B. Newton

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9. The SI unit for temperature is:

A. Celsius
B. Kelvin
C. Fahrenheit
D. Degree
E. Joule
Answer: B. Kelvin

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10. Which SI unit is used to measure frequency?

A. Radian

B. Tesla

C. Hertz

D. Pascal

E. Coulomb

Answer: C. Hertz

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11. The conversion factor between meters and kilometers is:

A. 10 meters = 1 kilometer

B. 100 meters = 1 kilometer

C. 1,000 meters = 1 kilometer

D. 10,000 meters = 1 kilometer

E. None of the above

Answer: C. 1,000 meters = 1 kilometer

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12. The unit of pressure in the SI system is:

A. Pascal
B. Newton
C. Watt
D. Joule
E. Coulomb
Answer: A. Pascal

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13. Which quantity is measured in coulombs?

A. Electric charge
B. Magnetic induction
C. Force
D. Energy
E. Voltage
Answer: A. Electric charge

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14. The symbol for the metric prefix "micro" is:

A. µ

B. m

C. µ

D. u

E. mc

Answer: A. µ

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15. In unit conversions, the ratio expressing how many of one unit equals another is called:

A. Scale factor

B. Conversion factor

C. SI unit

D. Derived unit

E. Standard factor

Answer: B. Conversion factor

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16. Which of the following quantities is NOT a fundamental physical quantity?

A. Length

B. Time

C. Speed

D. Mass

E. Electric current

Answer: C. Speed

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17. What is the SI unit of energy?

A. Newton

B. Joule

C. Watt

D. Volt

E. Coulomb

Answer: B. Joule

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18. A nanometer (10^{-9}) is smaller than a:

A. Millimeter
B. Micrometer
C. Picometer
D. Femtometer
E. None of the above
Answer: A. Millimeter

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19. Which of the following is a derived SI unit?

A. Second
B. Ampere
C. Volt
D. Mole
E. Meter
Answer: C. Volt

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20. The derived SI unit for electrical resistance is:

A. Siemens

B. Farad

C. Volt

D. Ohm

E. Henry

Answer: D. Ohm

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21. Which metric prefix represents 10^{12} ?

A. Giga

B. Tera

C. Mega

D. Peta

E. Exa

Answer: B. Tera

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22. What is the SI unit of luminous intensity?

A. Watt
B. Kelvin
C. Candela
D. Mole
E. Radian
Answer: C. Candela

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23. SI units allow scientists to:

A. Avoid performing conversions

B. Use random systems for calculations

C. Express and compare values meaningfully

D. Replace imperial systems entirely

E. Simplify experiments arbitrarily

Answer: C. Express and compare values meaningfully

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24. Which of the following represents 10^{-15} ?

A. Nano
B. Pico
C. Femto
D. Atto
E. Milli
Answer: C. Femto

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25. A measurement expressed as "0.08 km" is equivalent to:

A. 800 meters

B. 80 meters

C. 8 meters

D. 0.8 meters

E. None of the above

Answer: B. 80 meters