Chapter 1 Introduction

1.1 What is physics?

Physics deals with the behavior and composition of matter and its interactions **at the most fundamental level**.

Classical Physics

Classical physics: (1600 - 1900)

1. **Classical mechanics**: The study of the motion of particles and fluids.
2. **Thermodynamics**: The study of temperature, heat transfer, and the properties of aggregations of many particles.
3. **Electromagnetism**: Electricity, magnetism, electromagnetic waves, and optics.

Modern Physics

Modern physics: (1900 - now)

1. **Special Relativity** : A theory of the behavior of particles moving at high speeds. It led to a radical revision of our ideas of space, time, and energy.
2. **Quantum Mechanics**: A theory of submicroscopic world of the atoms. It also require a profound upheaval in our vision of how nature operates.
3. **General Relativity**: A theory that relates the force of gravity to the geometrical properties of space.

The basic interactions (I)

1. The **gravitational** interaction produces an attractive forces between all particles.
2. The **electromagnetic** interaction between electric charges is manifested in chemical reactions, light, radio and TV signals, friction, and all other forces we experience every day.
3. The **strong** interaction between quarks and most other sub-nuclear particles holds particles within the nucleus.
4. The **weak** interaction between quarks and leptons is associated with radioactivity.

Clearly, the dream of physicists is to discover a single fundamental interaction from which all forces can be derived.

The basic interactions (II)

TABLE 1.1 THE BASIC INTERACTIONS

Interaction	Relative Strength	Range
Strong	1	10^{-15} m
Electromagnetic	10^{-2}	Infinite
Weak	10^{-6}	10^{-17} m
Gravitational	10^{-38}	Infinite

1.2 Concepts, Models, and Theories

Concepts: A concept is an idea or a physical quantity that is used to analyze natural phenomena. (operational definitions)

Laws and Principles: A law is a mathematical relationship; a principle is a very general statement about how nature operates.

Models: A model is a convenient analog or representation of a physical system and can be useful even if it is incomplete or incorrect.

Theories: A theory uses a combined principles, a model, and initial assumptions to deduce specific consequences or laws (always tentative).

1.3 Units: Système International

The value of any physical quantity must be expressed in terms of some standard or **unit**.

MKSA unit system: All physical quantities can be expressed in terms of three fundamental quantities: Mass (kg), length (m), and time (s).

It is convenient to define additional base units: the kelvin (K) for temperature, the ampere (A) for electric current, and the candela (cd) for luminous intensity.

How about the gaussian unit system?

1.3 Units: Derived Units

DERIVED UNITS WITH SPECIAL NAMES

Quantity	Derived Unit	Name
Activity	1 decay/s	Bequerel (Bq)
Capacitance	C/V	farad (F)
Charge	A.s	coulomb (C)
Electric Potential; EMF	J/C	volt (V)
Energy, work	N.m	joule (J)
Force	$kg.m/s^2$	newton (N)
Frequency	l/s	hertz (Hz)
Inductance	V.s/A	henry (H)
Magnetic flux density	Wb/m^2	tesla (T)
Magnetic flux	V.s	weber (Wb)
Power	J/s	watt (W)
Pressure	N/m^2	pascal (Pa)
Resistance	V/A	ohm (Ω)

1.3 Units: Conversion of Units

Example: The wind speed measured at the ridge is 25 km/h and the recommended flying condition of paraglider is below 7 m/s for the intermediate pilot. Shall this pilot take off? (This is a common condition at the green bay.)

Solution:

$$25\ km/h = \left(\frac{25\ km}{h}\right)\left(\frac{1000\ m}{1\ km}\right)\left(\frac{1\ h}{3600\ s}\right)$$
$$= 6.94\ m/s \approx 7\ m/s$$

I will suggest this pilot not flying for the moment.

Standard Abbreviations for Units

STANDARD ABBREVIATIONS FOR UNITS

Ampere	A	Inch	in.
Angstrom	Å	Joule	J
Atomic mass unit	u	Kelvin	K
Atmosphere	atm	Kilocalorie	kcal (Cal)
British thermal unit	Btu	kilogram	kg
Coulomb	C	Pound	lb
Degree Celsius	°C	Meter	m
Electronvolt	eV	Minute	min
Degree Fahrenheit	°F	Mole	mol
Farad	F	Newton	N
Foot	ft	Ohm	Ω
Gauss	G	Pascal	Pa
Gram	g	Second	s
Henry	H	Tesla	T
Hour	h	Volt	V
Horsepower	hp	Watt	W
Hertz	Hz	Weber	Wb

The Greek Alphabet

THE GREEK ALPHABET

Alpha	Α	α	Iota	Ι	ι	Rho	Ρ	ρ
Beta	Β	β	Kappa	Κ	κ	Sigma	Σ	σ
Gamma	Γ	γ	Lambda	Λ	λ	Tau	Τ	τ
Delta	Δ	δ	Mu	Μ	μ	Upsilon	Υ	υ
Epsilon	Ε	ε	Nu	Ν	ν	Phi	Φ	φ
Zeta	Ζ	ζ	Xi	Ξ	ξ	Chi	Χ	χ
Eta	Η	η	Omicron	Ο	ο	Psi	Ψ	ψ
Theta	Θ	θ	Pi	Π	π	Omega	Ω	ω

1.4 Power of Ten Notation and Significant Figures

PREFIXES FOR POWERS OF TEN

Power	Prefix	Abbreviation	Power	Prefix	Abbreviation
10^{-18}	atto	a	~~10^{1}~~	~~deka~~	~~da~~
10^{-15}	femto	f	~~10^{2}~~	~~hecto~~	~~h~~
10^{-12}	pico	p	10^{3}	kilo	k
10^{-9}	nano	n	10^{6}	mega	M
10^{-6}	micro	μ	10^{9}	giga	G
10^{-3}	milli	m	10^{12}	tera	T
10^{-2}	centi	c	10^{15}	peta	P
10^{-1}	deci	d	10^{18}	exa	E

Numerical values obtained from the measurement always have some uncertainty.

Significant figures indicate the precision of data.

1.5 Order of Magnitude

Use to "guesstimate" the size of something only within a factor of ten.

Example 1.1: An engineer is designing a pacemaker for a cardiac patients. For a 20-year-old woman, how many times should the device have to beat for her to have normal life expectancy?

Solution: We require several estimates.

(a)Assuming that she lives to 80 years, the device must last at least 60 years.

(b)How many heart beat per minute? Say, 80 beat per minute.

(c)How many minutes per year? 60x24x365=525600 m/y

The total heart beats 60x80x525600 $\approx$ $3\text{x}10^9$

For the safety reason, I will design a pacemaker having 10^{10} beats guarantee before breaking down.

1.6 Dimensional Analysis

Each derived unit in mechanics can be reduced to factors of the base units mass (M), length (L), and time (T).

If one ignores the unit system, that is, whether it is SI or British, then the factors are called **dimension**.

For example: Newton's second law F=ma

Force: kg· m/s^2= MLT^{-2}

Acceleration: m/s^2= LT^{-2}

Left-hand side equals to the right-hand side.

An equation must be dimensionally consistent. It provides a quick check.

1.7 Reference Frames and Coordinate System

The position of a body has meaning only in relation to a frame of reference, which is something physical, such as a tabletop, a room, a ship, or the earth itself.

The position is specified with respected to a coordinate system that consists of a set of axes, each of which specifies a direction in space.

Three commonly employed coordinate systems are Cartesian (x, y, z), Cylindrical (r, θ, z), and Spherical (r, θ, Φ).

Historical note: The Geocentric Theory Versus the Heliocentric Theory

Even the great minds are confused before concepts get sorted out.

Physics is the end products of the labors of brilliant minds.

Chapter 2 Vectors: summary (I)

• A scalar is specified by a number and its unit. It has magnitude but no direction. It obeys the rules of ordinary algebra.

• A vector has magnitude and direction. It obeys the laws of vector algebra.

• In the tail-to-tip method of vector addition, the tail of each vector is placed at the tip of the preceding one.

• In three dimensions a vector may be expressed in unit vector notation: and its magnitude is

$$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k} \qquad A = \sqrt{A_x^2 + A_y^2 + A_z^2}$$

Chapter 2 Vectors: summary (II)

• The vector equation is equivalent to three equations:

$$\vec{R} = \vec{A} + \vec{B}$$

$$R_x = A_x + B_x \qquad R_y = A_y + B_y \qquad R_z = A_z + B_z$$

• The scalar (dot) product of two vectors is

$$\vec{A}\cdot\vec{B} = AB\cos\theta = A_xB_x + A_yB_y + A_zB_z$$

• The vector (cross) product of two vectors is

$$\vec{A}\times\vec{B} = AB\sin\theta\,\hat{\mathrm{n}}$$

where the direction of **n** is given by the right-hand rule.