Phys 103
General Physics(1)
(Mechanics)

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- Text book:

Physics for Scientists and Engineers 6 th Edition Raymond A. Serway

- Marks distribution:

1) One midterm exam 30 marks
2) Practical work (Lab.) 30 marks
3) Final exam 40 marks

Total 100 marks

Course outline

Chapter	Title	Section	Hours	Suggested problems
1	Physics and measurement	1.1, 1.4, 1.5	2	13,15,21,25,31
2	Motion in One Dimension	2.1, 2.2, 2.3, 2.5, 2.6	4	4,5,11,15,16,20,21,22,23,25,27,28,29,32,33,40,42,43,46,48,51,52
3	Vectors	3.1--to--3.4	4	1,4,19,21,27,30,31,33,39,49,50
4	Motion in Two Dimensions	4.1--to--4.5	4	1,3,5,6,8,14,15,17,19,20,22,23,25,29
5	The Laws of Motion	5.1--to--5.8	6	3,7,11,16,18,24,25,26,28,30,31,37,41,44,45,46,68
6	Circular Motion and Other Applications of Newton's Laws	6.1	2	1,2,5,7,59
7	Energy and Energy Transfer	7.2--to--7.8	4	1,4,7,13,14,15,16,19,21,24,25,26,28,31,32,33,35,37,40
8	Potential Energy	8.1--to--8.5	4	2,5,6,11,13,17,31,33,36,38,42,55,57,59,60
9	Linear Momentum and Collisions	9.1--to--9.4	5	1,2,4,5,7,8,9,10,13,15,16,17,18,21,25,27,32,33,35
10	Rotation of a Rigid Object About a Fixed Axis	10.1--to--10.8	6	1,3,5,6,8,12,13,16,17,18,20,21,31,35,37,46,70,71

Chapter 1

Physics and Measurement

LECTURE OUTLINE:

- 1.1 Standards of Length, Mass, and Time
- 1.4 Dimensional Analysis
- 1.5 Conversion of Units

1.1 Standards of Length, Mass, and Time

- In 1960, an international committee established a set of standards for the fundamental quantities of science. It is called the Système International (SI) Système International (SI), which are Length, Mass, and Time and its fundamental units are the meter (m), kilogram (kg), and second (s).
- Other standards for SI fundamental units are: Temperature (Kelvin), Electric current (Ampere), Luminous intensity (candela), and the Amount of substance (mole).

In mechanics, there are three basic quantities: length, mass, and time

- All other quantities in mechanics can be expressed in terms of these three.

- **Length**: SI Unit of length is: meter (m).
- **Mass**: SI Unit of mass is: kilogram (kg)
- **Time**: SI Unit of time is: second (s)

Derived Quantities

- When a quantity involves the measurement of 2 or more fundamental quantities it is called a Derived Quantity
- The units of these are called Derived Units

Example derived quantities & units:

Quantity	Law	Unit
Area	A = l x w	m^2
Volume	V = l x w x h	m^3
Speed or velocity	v = distance/time	m/s or ms^{-1}
Acceleration	a = velocity/time	m/s^2 or ms^{-2}
Momentum	p = mass x velocity	Kgm/s or $kgms^{-1}$
Density (mass/volume)	$\rho \equiv \frac{m}{V}$	kg/m3 or kgm^{-3}

Physical Quantities

Basic

Length (m), Mass (kg), Time (s)

Derived

Area (m^2), Volume (m^3), Velocity (m/s), Acceleration (m/s^2), momentum (kg m/s), Force (N), Work (J), ……

- In many situations, you may have to derive or check a specific equation. A useful and powerful procedure called dimensional analysis can be used to assist in the derivation or to check your final expression.
- As a simple method:

Left Hand Side must = Right Hand Side

1.4 Dimensional Analysis

- **Dimension:** it denotes the physical nature of a quantity
- **Example:** distance: could be in meters, yards, or micrometers. But over all it is: a **length**
- **Symbols we are going to use are:**

➢ dimension of length: **[L]**

➢ dimension of mass: **[M]**

➢ dimension of time: **[T]**

Basic Quantity

Quantity	Symbol	Unit	Dimension
Length	ℓ	meter (m)	L
Mass	m	kilogram (kg)	M
Time	t	second (s)	T

Derived Quantity

Units of Area, Volume, Velocity, Speed, and Acceleration

System	Area (L^2)	Volume (L^3)	Speed (L/T)	Acceleration (L/T^2)
SI	m^2	m^3	m/s	m/s^2
U.S. customary	ft^2	ft^3	ft/s	ft/s^2

Dimensional Analysis

- Dimensional Analysis is a technique to check the correctness of an equation or to assist in deriving an equation.
- Dimensions (length, mass, time, combinations) can be treated as algebraic quantities add (+), subtract (-), multiply (x), divide (:)
- Both sides of equation must have the same dimensions.

EXAMPLE:

- Given the equation: $\boldsymbol{x = \tfrac{1}{2} a t^2}$
  - Let say, x is distance traveled by a car in a time (t) if the car starts from rest and moves with constant acceleration (a).
- Check dimensions on each side:

$$L = \frac{L}{\cancel{T^2}} \cdot \cancel{T^2} = L$$

- The $\mathbf{T^2}$ cancel, leaving **L** for the dimensions of each side
  - Left hand side (LHS) = Right hand side (RHS)
  - The equation is dimensionally correct

Example 1.1 Analysis of an Equation

Show that the expression $v = at$, where v represents speed, a acceleration, and t an instant of time, is dimensionally correct.

SOLUTION

Identify the dimensions of v from Table 1.5: $[v] = \frac{\text{L}}{\text{T}}$

Identify the dimensions of a from Table 1.5 and multiply by the dimensions of t: $[at] = \frac{\text{L}}{\text{T}^{2}}\,\text{T} = \frac{\text{L}}{\text{T}}$

Therefore, $v = at$ is dimensionally correct because we have the same dimensions on both sides. (If the expression were given as $v = at^2$, it would be dimensionally *incorrect*. Try it and see!)

Example 1.2 Analysis of a Power Law

Suppose we are told that the acceleration a of a particle moving with uniform speed v in a circle of radius r is proportional to some power of r, say r^n, and some power of v, say v^m. Determine the values of n and m and write the simplest form of an equation for the acceleration.

Solution:

$a \propto r^n v^m \Rightarrow a = k\, r^n v^m$

Dim. of L.H.S = Dim. of R.H.S

$[a] = [k\, r^n v^m]$

$L T^{-2} = L^n (L T^{-1})^m$

$L T^{-2} = L^n L^m T^{-m}$

$L T^{-2} = L^{n+m} T^{-m}$

$$L^1 T^{-2} = L^{n+m} T^{-m}$$

So,

$$L^1 = L^{n+m}$$

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

from L $\Rightarrow$ $1 = n + m$ & from T $\Rightarrow$ $-2 = -m$ $\therefore m = 2$

$1 = n + 2$ $\therefore n = -1$

$a = k\, r^n v^m$ $\therefore a = k\, r^{-1} v^2$ $\therefore a = k \dfrac{v^2}{r}$

- An example is a kinematic equation for the velocity *v* of a uniformly accelerated body,

$$v = v_0 + at$$

where v_0 is the initial velocity, *a* the acceleration and *t* the time interval. In terms for dimensions of the equation, we can expand that: $[v] = [v_o] + [at]$

Then, $$LT^{-1} = LT^{-1} + LT^{-2} \bullet T$$

$$LT^{-1} = LT^{-1} + LT^{-1} \Rightarrow \boxed{LT^{-1} = LT^{-1}}$$

LHS = RHS, equation is correct.

1.5 Conversion of Units

Some times it is necessary to convert units from one measurement system to another, or to convert within a system, for example, from kilometers to meters.

Examples:1 mile = 1 609 m = 1.609 km

- 1 ft = 0.304 8 m = 30.48 cm
- 1 m = 39.37 in. = 3.281 ft
- 1 in. = 0.025 4 m = 2.54 cm (exactly)

Converting TIME units

1 hour = 60 minutes
1 minute = 60 seconds

Then,
1 h = 60 min = (60)(60) s
= 3600 s

Example:
Speed of a car is **60 km/h**, what is it speed in **m/s**?

Answer:
60 km/h = (60)(1000) m/(60)(60) s
= (60000 m)/(3600 s)
= **16.67 m/s**

Then, **60 km/h = 16.67 m/s**

Table 1.4

Prefixes for Powers of Ten

Power	Prefix	Abbreviation
10^{-24}	yocto	y
10^{-21}	zepto	z
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{-1}	deci	d
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zetta	Z

Proplem Section 1.5 Conversion of Units

21. A rectangular building lot is 100 ft by 150 ft. Determine the area of this lot in m^2.

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25. A solid piece of lead has a mass of 23.94 g and a volume of 2.10 cm^3. From these data, calculate the density of lead in SI units (kg/m^3).

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31. One gallon of paint (volume=3.78×10^{-3} m^3) covers an area of 25.0 m^2. What is the thickness of the paint on the wall?