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Physics-I

Useful Book : Fundamentals of Physics
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& Robert Resnik

Chapter 1
Measurement

1-1 Measuring Things:

To describe a physical quantity we define;

i) Unit: A measure of the quantity that is defined to be exactly 1.0 .

ii) Standard: A reference to which all other examples of the quantity are compared.

1-2 The International system of Units:

In 1971, 14th General Conference on Weights and Measures

⟶ picked 7 quantities as base quantities

⟶ forming the basis of the International System of Units (SI or metric system).

Three of them:

Quantity	Unit name	Unit symbol
Length	meter	m
Time	Second	s
Mass	Kilogram	kg

Prefixes for SI Units

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

1-3 Changing Units:

Chain-link Conversion Method:

In this method the original quantity is multiplied by a <u>Conversion factor</u> (a ratio of units that is equal to <u>unity</u>)

<u>Ex.</u> $\frac{1 \text{ min}}{60 \text{ S}} = 1$ or $\frac{60 \text{ S}}{1 \text{ min}} = 1$

$\rightarrow$ $2 \text{ min} = (2 \text{ min})(1) = (2 \cancel{\text{min}})\left(\frac{60 \text{ S}}{1 \cancel{\text{min}}}\right) = 120 \text{ S}$.

Sample Prob. 1-1

$V = 36.5$ fathoms/minute

a) $V \stackrel{?}{=} m/s$ (1 fathom = 6 ft)

$$36.5\ \frac{fath}{min} = \left(36.5\ \frac{fath}{min}\right)\left(\frac{1\ min}{60\ s}\right)\left(\frac{6\ ft}{1\ fath}\right)\left(\frac{1\ m}{3.28\ ft}\right)$$

$= 1.11\ m/s$

b) $V \stackrel{?}{=} \frac{miles}{hour}$

$$36.5\ \frac{fath}{min} = \left(36.5\ \frac{fath}{min}\right)\left(\frac{60\ min}{1\ h}\right)\left(\frac{6\ ft}{1\ fath}\right)\left(\frac{1\ mi}{5280\ ft}\right) = 2.49\ mi/h$$

c) $V \stackrel{?}{=} \frac{light\text{-}year}{year}$ $ly = 9.46 \times 10^{12}\ km$

$$1.11\ \frac{m}{s} = \left(1.11\ \frac{m}{s}\right)\left(\frac{1\ ly}{9.46 \times 10^{12}\ km}\right)\left(\frac{1\ km}{1000\ m}\right)\left(\frac{3.16 \times 10^{7}\ s}{1\ y}\right)$$

$= 3.71 \times 10^{-9}\ ly/y$

Since we have 3-significant figures in our original data 36.5, all the results can not have number of figures more than this.

Sample prob. 1-2

$S = 6.0\ km^2 \qquad S \stackrel{?}{=} cm^2$

Sol.

$$6.0\ km^2 = 6.0\,(1km)(1km)\left(\frac{1000\ m}{1\ km}\right)\left(\frac{1000\ m}{1\ km}\right)\left(\frac{100\ cm}{1\ m}\right)\left(\frac{100\ cm}{1\ m}\right)$$

$$= 6.0 \times 10^{10}\ cm^2$$

Sample Prob. 1-3

$V = 60\ mi/h \qquad V \stackrel{?}{=} feet/s$

Sol.

$$60\ mi/h = (60\ mi/h)\underbrace{\left(\frac{3.28\ ft/s}{2.24\ mi/h}\right)}_{\text{unity}} = 88\ ft/s$$

1-4 Length

1972, France

1 meter $= \frac{1}{10^7}$ distance between the north pole and the equator.

later → The length of platinum-iridium bar (standard meter bar) kept in International Bureau of Weights and Measures near Paris.

In 1959; the yard was legally defined to be

$$1 \text{ Yard} = 0.9144 \text{ meter} \quad \text{(exactly)}$$

which is equivalent to

$$1 \text{ inch} = 2.54 \text{ centimeters} \quad \text{(exactly)}$$

New standard; (1960)

$$1 \text{ meter} = 1,650,763.73 \ \lambda$$

λ: wavelength of a particular orange-red light emitted by ^{86}Kr.

^{86}Kr atoms are available everywhere and more secure.

1983, the 17th General Conference on Weights and Measures:

The meter is the length of the path traveled by light in vacuum during a time interval of $\frac{1}{299,792,458}$ s

$$c = 299,792,458 \text{ m/s}$$

1-5 Time

1967, the 13th General Conference on Weights and Measures;

One Second is the Time taken by 9,192,631,770 vibrations of the light (of a specific wave-length) emitted by ^{133}Cs-atom

→ accuracy 1 S in 6000 Yr

Recent developed clocks have the accuracy 1 S in 10^{18} S (3×10^{10} Yr)

Sample prob. 1-5

light-fermi = the time taken by light to travel a distance of 1 fermi (= 1 femtometer = 1 fm = 10^{-15} m)

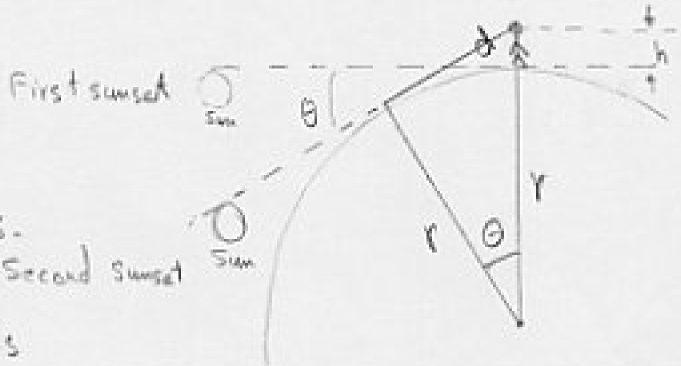
1 light-fermi $\overset{?}{=}$ Sec

Sol.

$$1 \text{ light-fermi} = \frac{1\ \text{fm}}{c} = \frac{10^{-15}\ \text{m}}{3.00\times10^{8}\ \text{m/s}} = 3.33\times10^{-24}\ \text{S}$$

Sample Prob. 1-6

Suppose that you watch the sunset over a calm ocean while lying on the beach, starting a stopwatch just as the to of the sun disappears. You then stand, elevating your eyes by a height $h = 1.70$ m, and stop the watch when the top of the sun again disappears. If the elapsed time on the watch is $t = 11.1$ s, what is the radius r of the Earth?



Sol.

$$d^2 + r^2 = (r+h)^2 = r^2 + h^2 + 2rh \rightarrow d^2 = 2rh + h^2 \approx 2rh$$

$$\frac{\theta}{360°} = \frac{t}{24h} \qquad \theta = \frac{(360°)(11.1s)}{(24h)(60\,min/h)(60s/min)} = 0.04625°$$

Also $d = r\tan\theta \rightarrow r^2\tan^2\theta = 2rh \rightarrow r = \frac{2h}{\tan^2\theta}$

$$r = \frac{2(1.70m)}{\tan^2(0.04625)} = 5.22 \times 10^6\ m$$

($r = 6.37 \times 10^6$ m mean radius of the Earth)

1-6 Mass

The standard Kilogram

A platinum-iridium cylinder Kept at the International Bureau of Weights and Measuers near paris.

A second Mass Standard;

The mass of ^{12}C-atom $= 12\,u$

$1u = 1.6605402 \times 10^{-27}$ kg , atomic mass unit