

Chapter 22 – 24: Units

	MKS Practical (SI)	CGS Electrostatic (esu)	CGS Electromagnetic (emu)
Magnetic field (= flux density)	T $\left(= \text{Tesla} = \frac{\text{Wb}}{\text{m}^2} \right)$	No units defined in the esu system	gauss
Force	N $\left(= \text{Newton} = \frac{\text{kg}\cdot\text{m}}{\text{s}^2} \right)$	dyne $\left(= \frac{\text{g}\cdot\text{cm}}{\text{s}^2} \right)$	dyne
Torque	N·m	dyne·cm	dyne·cm
Magnetic dipole moment	A·m ² $\left(= \frac{\text{N}\cdot\text{m}}{\text{Tesla}} \right)$	Statamp·cm ²	Abamp·cm ²
Magnetic flux	Weber (= T·m ²)	Statvolt	Abvolt
Inductance	Henry (=H)	Stathenry	Abhenry
Frequency	Hz (= 1/sec)	Hz	Hz
Angular frequency (= ω)	$\frac{\text{rad}}{\text{s}}$	$\frac{\text{rad}}{\text{s}}$	$\frac{\text{rad}}{\text{s}}$
Resistance, Reactance, Impedance	Ohm (= Ω)	Statohm	Abohm
Phase Angle	Degree (°)	Degree (°)	
Power	Watt $\left(= \frac{\text{J}}{\text{s}} \right)$	$\frac{\text{erg}}{\text{s}}$	$\frac{\text{erg}}{\text{s}}$
Power factor	No units	No units	No units
Electric flux	$\frac{\text{N}\cdot\text{m}^2}{\text{C}}$	$\frac{\text{dyne}\cdot\text{cm}^2}{\text{StatC}}$ (=StatC)	$\frac{\text{dyne}\cdot\text{cm}^2}{\text{Abcoulomb}}$
Energy density	$\frac{\text{J}}{\text{m}^3}$	$\frac{\text{erg}}{\text{cm}^3}$	$\frac{\text{erg}}{\text{cm}^3}$

Constants:

ϵ_0 = permittivity of free space = 8.854×10^{-12} Farad/m (Farad/m = C²/N·m²)

$k = (1/4\pi\epsilon_0) = 8.988 \times 10^9$ m/Farad (m/Farad = N·m²/C²)

μ_0 = permeability of free space = $4\pi \times 10^{-7}$ Henry/m (Henry/m = N·m/A²)

Derivation of esu and emu units

Electrostatic units are derived using the assumption that $k = (1/4\pi\epsilon_0) = 1$. Coulomb's force law (in esu units) defines the statcoulomb:

$$F = \frac{q_1 q_2}{r^2} \left(\text{that is, } 1 \text{ dyne} = \frac{\text{statcoulomb}^2}{\text{cm}^2} \right).$$

Electromagnetic units are derived using the assumption that $(\mu_0/4\pi) = 1$. The force per unit length between two parallel currents (in emu units) defines the abamp:

$$\frac{F}{L} = \frac{2 I_1 I_2}{r} \left(\frac{\text{dyne}}{\text{cm}} = \frac{\text{abamp}^2}{\text{cm}} \right).$$

All other electrical units in the esu system are derived from the definition of the statcoulomb and all other electrical units in the emu system are derived from the definition of the abamp.

CONVERSION CHART

PRACTICAL (SI)	ELECTROSTATIC (esu)	ELECTROMAGNETIC (emu)
1 Coulomb	= 2.998×10^9 Statcoulombs	= 10^{-1} Abcoulomb
1 Ampere	= 2.998×10^9 Statamps	= 10^{-1} Abamp
1 Ohm	= $\frac{1}{8.988 \times 10^{11}}$ Statohm	= 10^9 Abohms
1 Farad	= 8.988×10^{11} Statfarads	= 10^{-9} Abfarads
1 Volt	= $\frac{1}{299.8}$ Statvolt	= 10^8 Abvolts
1 Tesla	= $\frac{1}{2.998 \times 10^6}$	= 10^4 Gauss
1 Henry	= $\frac{1}{8.988 \times 10^{11}}$ Stathenry	= 10^9 Abhenrys

Prefixes and Greek letters:

tera (T) = 10^{12}	kilo (k) = 10^3	micro (μ) = 10^{-6}
giga (G) = 10^9	centi (c) = 10^{-2}	nano (n) = 10^{-9}
mega (M) = 10^6	milli (m) = 10^{-3}	pico (p) = 10^{-12}

α A Alpha	η H Eta	ν N Nu	τ T Tau
β B Beta	θ Θ Theta	ξ Ξ Xi	υ Y Upsilon
γ Γ Gamma	ι I Iota	\omicron O Omicron	ϕ Φ Phi
δ Δ Delta	κ K Kappa	π Π Pi	χ X Chi
ϵ E Epsilon	λ Λ Lambda	ρ P Rho	ψ Ψ Psi
ζ Z Zeta	μ M Mu	σ Σ Sigma	ω Ω Omega