B

Michel 1/28/64

SPACE SCIENCE 500

Supplement

Rationalized MKSC

Length in Meters (m), Mass in Kilograms (kg), Time in Seconds (sec), Charge in Coulombs, Force in Newtons (kg-m/sec^2). Energy in Joules (kg-m^2/sec^2).

Differential Equations:

$\underline{\nabla} \cdot \underline{E} = \rho/\epsilon_o$ $[\rho]$ = 1 Coulomb/m^3

$\underline{\nabla} \cdot \underline{B} = 0$

$\underline{\nabla} \times \underline{E} = - \partial\underline{B}/\partial t$

$\underline{\nabla} \times \underline{B} = \mu_o \underline{J} + \mu_o \epsilon_o \partial\underline{E}/\partial t$ $[J]$ = 1 Amp/m^2 $\mu_o \epsilon_o = 1/c^2$

$\underline{D} \equiv \epsilon_o \underline{E}$, $\underline{B} \equiv \mu_o \underline{H}$ $c = 3 \times 10^8$ m/sec, 1Coulomb/sec = 1 Amp

Force:

$\underline{F} = q\underline{E}$ $[E]$ = Newton/Coulomb ≡ Volt/m

1 Volt.Coulomb = 1J

$\underline{E} = q/4\pi\epsilon_o r^2$ $4\pi\epsilon_o = \frac{1}{9} \times 10^{-9}$ Coulomb/Volt·m or Farad/m

F ≡ Farad

$\underline{F} = q(\underline{v} \times \underline{B})$ $[B]$ = Weber/m^2 (10^{+4} G = 10^9 γ)

1 Weber ≡ Volt-sec (= 10^4 Guass = 10^9 gamma)

v = Velocity in m/sec

$[H]$ = Amp/m

Energy Density:

$$u = \frac{B^2}{2\mu_o} \text{ or } \tfrac{1}{2}\,\underline{B}.\underline{H} \qquad (1 \text{ Joule/m}^3 = 1 \text{ Weber}^2/\text{Henry m}^3)$$

$$+ \frac{\epsilon_o E^2}{2} \text{ or } \tfrac{1}{2}\,\underline{E}.\underline{D} \qquad (1 \text{ Coulomb-Volt/m}^3 = 1 \text{ Joule/m}^3)$$

$$\underline{S} = (\underline{E} \times \underline{H}) = \frac{1}{\mu_o}(\underline{E} \times \underline{B})$$

$$\mu_o = 4\pi \times 10^{-7} \text{ Kg-m/Coulomb } (= \text{Henry/m})$$

Ohm's Law

$V = IR$

$I = dQ/dt = \int \underline{J}.d\underline{s}$

$[I] = 1$ Amp $\equiv 1$ Coulomb/S

$[J] = 1$ Amp/m^2

$[R] = 1$ Ohm $\equiv 1$ Volt/Amp

$\underline{J} = \sigma\underline{E}$

$[\sigma] = 1$/Ohm - m

Fundamental Units:

$e = 1.60206 \times 10^{-19}$ Coulomb = electric charge

$m = 9.1083 \times 10^{-31}$ kg = mass of electron

$M = 1.67239 \times 10^{-27}$ kg = mass of proton

$k = 1.38 \times 10^{-23}$ J/°K

$\frac{e^2}{4\pi\epsilon_0} = 1.44 \times 10^{-7}$ eV-cm

Conversion Factors (all are unity):

$1 = 1.60206 \times 10^{-19}$ Joule/electron-volt

$= 10^5$ dyne/Newton

$= 10^7$ erg/Joule

$= 300$ volt/Statvolt

$= 3 \times 10^9$ statcoulomb/Coulomb

$= 10$ Abcoulomb/Coulomb

Nomenclature:

$\underline{E}$ is electric field intensity

$\underline{D}$ is displacement

$\underline{B}$ is magnetic field intensity

$\underline{H}$ is magnetic induction

Vector Identities

1. $\underline{A} \times (\underline{B} \times \underline{C}) = \underline{B}\ (\underline{A}.\underline{C}) - \underline{C}\ (\underline{A}.\underline{B})$
2. $\nabla . (\nabla \times \underline{A}) = 0$
3. $\nabla \cdot (S\underline{A}) = S\ \nabla . \underline{A} + \underline{A}\ .\ (\nabla S)$ S = scalar function
4. $\nabla . (\underline{A} \times \underline{B}) = \underline{B} . (\nabla \times \underline{A}) - \underline{A}\ .\ (\nabla \times \underline{B})$
5. $\nabla \times (\nabla S) = 0$
6. $\nabla \times (S\underline{A}) = S(\nabla \times \underline{A}) + (\nabla S) \times \underline{A}$
7. $\nabla \times (\nabla \times \underline{A}) = \nabla (\nabla . \underline{A}) - \nabla^2 \underline{A}$
8. $\nabla \times (\underline{A} \times \underline{B}) = \underline{A}\ (\nabla . \underline{B}) - \underline{B}\ (\nabla . \underline{A}) + (\underline{B} \cdot \nabla)\underline{A} - (\underline{A} \cdot \nabla)\underline{B}$
9. $\nabla (\underline{A}.\underline{B}) = (\underline{A} . \nabla)\underline{B} + (\underline{B} . \nabla)\ \underline{A} + \underline{A} \times (\nabla \times \underline{B}) + \underline{B} \times (\nabla \times \underline{A})$
10. $\nabla f\ (u) = \frac{\partial f}{\partial u} \nabla u$
11. $\nabla . \underline{F}\ (u) = \nabla u . \partial \underline{F} / \partial u$
12. $\nabla \times \underline{F}\ (u) = \nabla u \times \partial \underline{E} / \partial u$
13. $\underline{A} . (\underline{B} \times \underline{C}) = (\underline{A} \times \underline{B})\ .\ \underline{C} = -\ (\underline{A} \times \underline{C})\ . \underline{B}$, etc.

$\underline{A} . \nabla \equiv a_x \partial_x + a_y \partial_y + a_z \partial_z$