APPENDIX A

Dimensions and MKS-type Units for Mechanics, Electricity and Magnetism, and Thermal Physics

Many introductory physics textbooks begin with a discussion of the dimensions and the small number of dimensionful units necessary to fully describe physical quantities. In this Appendix we briefly review and collect some of the dimensional equivalences which readers may find useful in solving problems or checking derivations. We then collect the values of important physical constants, in these units, in Appendix B.

For purely mechanical systems, the standard MKS set of units, using the meter (m), kilogram (kg), and second (s) as basic dimensionful quantities, is presumably familiar. We collect below some of the more important connections.

The extension to include a fundamental dimension related to electromagnetism (advocated by Giorgi, and included in the MKSA system) uses the Ampere (A) as the basic quantity, but for purposes of simplicity, we will here use the basic unit of charge, the Coulomb (C), noting that the substitution $C = A \cdot s$ allows one to translate. For thermal physics problems, the degree Kelvin (or kelvin, here written simply as K) is used. We will not require the two additional basic units (candela and mole) used in the Systéme Internationale (SI) d'Unités.

For completeness, we note that many of the standard electromagnetic relationships, in these units, are given through the textbook, namely

- the Coulomb force and potential are given by Eqns (1.28) and (1.29), respectively the Lorentz force law is given by Eqn. (18.5),
- Maxwell's equations are given by Eqns. (18.6)–(18.9),
- the Poynting vector is given by Eqn. (18.19),
- the scalar (ϕ) and vector ($\mathbf{A}$) potentials are given by Eqns (18.28) and (18.29)

Table A.1. Dimensions for quantities in mechanics

Quantity	Symbol (Name)	Units
Mass		kg
Length		m
Time		s
Speed	v	m/s
Acceleration	a	m/s^2
Force	F (Newton)	kg · m/s^2
Energy	E (Joule)	N · m or J
Power	P (Watt)	J/s or N · m/s
Momentum	p	kg · m/s or N/s
Moment of inertia	I	kg · m^2
Angular momentum	L	kg · m^2/s
Wavelength	λ	m
Wave number	k, κ	1/m
Frequency	f (Hertz)	1/s
Angular frequency	$\omega = 2\pi f$	rad/s

Table A.2. Dimensions of quantities in electromagnetism and thermal physics

Quantity	Symbol (Name)	Units
Charge	q (Coulomb)	C
Current	I (Ampere)	A = C/s
Electric potential	V (Volt)	J/C or V
Electric field	E	N/C or V/m
Electric dipole moment	p	C · m
Electric quadrupole moment	Q	C · m^2
Electric permittivity	ϵ	C^2/(N · m^2)
Capacitance	F (farad)	C/V or C^2/J
Resistance	Ω (Ohm)	V/A or J · s/C^2
Electrical resistivity	ρ	Ω · m or J · s · m/C^2
Electrical conductivity	σ	A/(m · V) or C^2/(J · m · s)
Magnetic field (induction)	T (Tesla)	N · s/(C · m)
Magnetic permeability	μ	N · s^2/C^2
Magnetic flux	Φ_B	Tesla ·m^2 or N · m ·/C^2
Magnetic dipole moment	m	A ·m^2 or C · m^2/s
Magnetic permeability	μ	N · s^2/C^2
Auxiliary magnetic field	H	A/m or C/(m · s)
Poynting vector	$E \times H$	J/(m^2 · s)
Degree (absolute scale)	Kelvin	K

A.1 Problems

PA.1 Dimensions for familiar quantities I. Add entries to Table A.1 for (a) pressure, (b) density, and (c) torque.

PA.2 Dimensions for familiar quantities II. Add entries to Table A.2 for (a) thermal conductivity, (b) specific heat, and (c) entropy. (You may have to look up some definitions for these.)