Equations by Topic

Physics 104

(you will not have access to this for exams)

Contents

Chapter 1

Electricity

1.1 Coulomb's Law

$$F = k\frac{|qQ|}{r^2}$$

1.2 Electric Field

1.2.1 Electric Field Created by a Point Charge

$$E = k\frac{|Q|}{r^2}$$

1.2.2 Electric Field Created by a Charged Plate

$$E = \frac{|\sigma|}{2\epsilon_0} = 2\pi k\,|\sigma|$$

1.2.3 Lorentz Force Law

$$\vec{\mathbf{F}} = q\vec{\mathbf{E}}$$

1.3 Electric Potential Energy

$$\mathrm{PE} = k\frac{qQ}{r}$$

1.4 Electric Potential

1.4.1 Electric Potential Created by a Point Charge

$$V = k\frac{Q}{r}$$

1.4.2 Electric Potential Created by a Charged Plate

$$V = -2\pi k\sigma\,|x|$$

1.4.3 EPE from Electric Potential

$$\text{PE} = qV$$

1.5 Capacitors

$$\Delta V = Ed \qquad Q = C\Delta V$$

$$C = \epsilon_0\frac{A}{d} \qquad \text{PE} = \frac{1}{2}Q\Delta V = \frac{1}{2}C(\Delta V)^2 = \frac{1}{2}\frac{Q^2}{C}$$

Chapter 2

Electric Circuits

2.1 Ohm's Law

$$V = IR$$

2.2 Resistivity

$$R = \frac{\rho L}{A}$$

2.3 Electric Power

$$P = IV = I^2R = \frac{V^2}{R}$$

2.4 Alternating Current

$$I_{\text{rms}} = \frac{I_0}{\sqrt{2}} \qquad V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$$

2.5 Equivalent Resistance

$$R_{\text{eq}} = R_1 + R_2 \qquad R_{\text{eq}} = \frac{R_1 R_2}{R_1 + R_2}$$

Chapter 3

Magnetism

3.1 Force between Two Current-Carrying Wires

$$F = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{d}l$$

3.2 Magnetic Field

3.2.1 Magnetic Field Created by a Straight Wire

$$B = \frac{\mu_0 I}{2\pi r}$$

3.2.2 Magnetic Field Created by a Solenoid

$$B = \mu_0 N I/l$$

3.2.3 Lorentz Force Law for Magnetism

$$F = |q|\, vB \sin\theta \qquad\qquad F = IlB \sin\theta$$

3.3 Faraday's Law of Induction

$$\Phi_B = BA\cos\theta \qquad\qquad \mathcal{E} = -N\frac{\Delta\Phi_B}{\Delta t}$$

3.4 Generators

$$\Phi_B = BA\cos\omega t \qquad\qquad \mathcal{E} = NB\omega A\sin\omega t$$

Chapter 4

Optics

4.1 Geometrical Optics

4.1.1 Snell's Law

$$n = \frac{c}{v}$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \qquad \sin\theta_C = \frac{n_2}{n_1}$$

4.1.2 Thin Lenses

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

4.1.3 Spherical Mirrors

$$f = \frac{r}{2}$$

4.1.4 Conventions

- The focal length f is positive for concave mirrors and converging lenses, and negative for convex mirrors and diverging lenses.

- For a single-lens or single-mirror system, we choose $d_o > 0$.
- A real image has $d_i > 0$, while a virtual image has $d_i < 0$.
- An upright image has $h_i > 0$, while an inverted image has $h_i < 0$.

4.2 Wave Optics

4.2.1 Double-Slit Interference

$$\lambda_n = \frac{\lambda}{n}$$

$$\#\lambda\text{s} = \frac{d \sin\theta}{\lambda}$$

4.2.2 Thin-Film Interference

$$\#\lambda\text{s} = \frac{2tn}{\lambda_0} + \left\{ \begin{array}{c} 1/2 \\ 0 \end{array} \right\} + \left\{ \begin{array}{c} 1/2 \\ 0 \end{array} \right\}$$

4.2.3 Single-Slit Diffraction

$$\sin\theta = \frac{\lambda}{D}$$

Chapter 5

Atomic and Nuclear Physics

5.1 Photoelectric Effect

$$E = hf \qquad\qquad p = \frac{E}{c} = \frac{hf}{c} = \frac{h}{\lambda}$$

5.2 Bohr Model

$$E_n = -(13.6 \text{ eV})\frac{Z^2}{n^2}$$

5.3 Decay Rates and Half-Life

$$N = N_0 e^{-\lambda t} \qquad\qquad T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$$

From Giancoli 7th, Appendix B

Atomic Number Z	Element	Symbol	Mass Number A	Atomic Mass†	Half-life (if radioactive)
0	(Neutron)	n	1	1.008665	10.183 min
1	Hydrogen	H	1	1.007825	
	proton	p	1	1.007276	
	Deuterium	${}^{2}_{1}$H	2	2.014102	
	Tritium	${}^{3}_{1}$H	3	3.016049	12.32 yr
2	Helium	He	3	3.016029	
			4	4.002603	
6	Carbon	C	11	11.011434	20.334 min
			12	12.000000	
			13	13.003355	
			14	14.003242	5730 yr
82	Lead	Pb	206	205.974466	
			207	206.975897	
			208	207.976652	
			210	209.984189	22.20 yr
			211	210.988737	36.1 min
			212	211.991898	10.64 h
			214	213.999806	26.8 min
84	Polonium	Po	210	209.982874	138.376 days
			214	213.995202	164.3 μs
85	Astatine	At	218	218.008695	1.5 s

†Masses given are those for the neutral atom, including the Z electrons (except for the proton).

Chapter 6

Physical Constants

Electron mass	9.11×10^{-31} kg
Proton mass	1.6726×10^{-27} kg
Neutron mass	1.6749×10^{-27} kg
Atomic mass unit (1 u)	1.6605×10^{-27} kg $= 931.5$ MeV$/c^2$
Proton charge	1.602×10^{-19} C
Electrical constant	$k = 8.988 \times 10^{9}$ N·m^2/C^2
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12}$ C^2/N·m^2
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ T·m/A
Gravitational constant	$G = 6.67 \times 10^{-11}$ N·m^2/kg^2
Planck's constant	$h = 6.63 \times 10^{-34}$ J·s
Speed of light in vacuun	$c = 3.00 \times 10^{8}$ m/s

$$1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$$

Material	Resistivity, ρ
Silver	1.59×10^{-8} Ω·m
Copper	1.68×10^{-8} Ω·m
Gold	2.44×10^{-8} Ω·m
Tungsten	5.6×10^{-8} Ω·m

Medium	Index of refraction, n
Vacuum	1.0000
Air (at STP)	1.0003
Water	1.33
Lucite	1.51
Crown glass	1.52