Physics 102 Formula Sheet

Coulomb's law (21-1, 2): $F = k\dfrac{Q_1 Q_2}{r^2} = \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q_1 Q_2}{r^2}$ (magnitude)

Torque on an electric dipole (21-9a): $\tau = pE\sin\theta, \quad p = Ql$

Potential energy of an electric dipole (21-10): $U = -pE\cos\theta = -\vec{p}\cdot\vec{E}$

Gauss's law (22-1-4): $\Phi_E = \sum \vec{E}\cdot\vec{A} = \dfrac{Q_{encl}}{\varepsilon_0}$

Electric potential due to a point charge (23-5): $V = \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q}{r}$ (assuming $V = 0$ at $r = \infty$)

Capacitance (24-1): $Q = CV$

Parallel-plate capacitor (24-2): $C = \varepsilon_0\dfrac{A}{d}$

Cylindrical capacitor (page 631): $C = \dfrac{2\pi\varepsilon_0 l}{\ln(R_a / R_b)}$

Capacitors in parallel (24-3): $C_{eq} = C_1 + C_2 + C_3$

Capacitors in series (24-4): $\dfrac{1}{C_{eq}} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \dfrac{1}{C_3}$

Energy stored in a capacitor (24-5): $U = \dfrac{1}{2}QV = \dfrac{1}{2}CV^2 = \dfrac{1}{2}\dfrac{Q^2}{C}$

Ohm's law (25-2): $I = \dfrac{V}{R}, \quad V = IR$

Resistivity (25-3): $R = \rho\dfrac{l}{A}$

Conductivity (25-4): $\sigma = \dfrac{1}{\rho}$

Electric power (25-6,7): $P = IV = I^2R = \dfrac{V^2}{R}$

Root-mean-square (rms) value (25-9): $I_{rms} = \dfrac{I_0}{\sqrt{2}}, \quad V_{rms} = \dfrac{V_0}{\sqrt{2}}$

Resistors in series (26-3): $R_{eq} = R_1 + R_2 + R_3$

Resistors in parallel (26-4): $\dfrac{1}{R_{eq}} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Time constant of RC circuits (26-7): $\tau = RC$

Charging of RC circuits (26-6b, 26-8): $V_C = \varepsilon\left(1 - e^{-t/RC}\right); \qquad I = \dfrac{\varepsilon}{R}e^{-t/RC}.$

Discharging of RC circuits (26-9b, 26-10): $V_C = V_0 e^{-t/RC}; \qquad I = I_0\, e^{-t/RC} = \dfrac{Q_0}{RC}e^{-t/RC}.$

Magnetic force on an electric current

$$F = IlB\sin\theta \qquad \textbf{(27-1)}$$

Magnetic force on a moving charge

$$\vec{F} = q\vec{v}\times\vec{B} \qquad \textbf{(27-5)}$$

Torque on a current loop due to a magnetic field

$$\tau = NIAB\sin\theta \qquad \textbf{(27-9)}$$

Magnetic dipole moment

$$\vec{\mu} = NI\vec{A} \qquad \textbf{(27-10)}$$

Magnetic field due to a long straight wire

$$B = \frac{\mu_0}{2\pi}\frac{I}{r} \qquad \textbf{(28-1)}$$

Ampere's law

$$\sum B_{\parallel}\Delta l = \mu_0 I_{encl} \qquad \textbf{(28-3)}$$

Magnetic field in a long solenoid

$$B = \frac{\mu_0 IN}{l} = \mu_0 In \qquad \textbf{(28-4)}$$

Magnetic flux

$$\Phi_B = B_{\perp}A = BA\cos\theta \qquad \textbf{(29-1)}$$

Faraday's law

$$\varepsilon = -N\frac{d\Phi_B}{dt} \qquad \textbf{(29-2)}$$

Speed, wavelength and frequency of a wave

$$c = \lambda f \qquad \textbf{(31-4)}$$

Focal length of a spherical mirror

$$f = \frac{r}{2} \qquad \textbf{(32-1)}$$

The mirror equation; thin lens equation

$$\frac{1}{d_o}+\frac{1}{d_i}=\frac{1}{f} \qquad \textbf{(32-2, 33-2)}$$

$$m = \frac{h_i}{h_o} = -\frac{d_i}{d_o} \qquad \textbf{(32-3, 33-3)}$$

Snell's law

$$n_1\sin\theta_1 = n_2\sin\theta_2 \qquad \textbf{(32-5)}$$

Wavelength in medium:

$$\lambda_n = \frac{\lambda}{n} \qquad \textbf{(34-1)}$$

Constructive interference of double-slit experiment

$$d\sin\theta = m\lambda \qquad m = 0, 1, 2, \ldots \qquad \textbf{(34-2a)}$$

Destructive interference of double-slit experiment

$$d\sin\theta = \left(m+\frac{1}{2}\right)\lambda \qquad m = 0, 1, 2, \ldots \qquad \textbf{(34-2b)}$$

Minima of single-slit diffraction

$$D\sin\theta = m\lambda \qquad m = \pm 1, \pm 2, \pm 3, ... \qquad \textbf{(35-2)}$$

Intensity of single-slit diffraction

$$I_\theta = I_0 \left[\frac{\sin\left(\frac{\pi D \sin\theta}{\lambda}\right)}{\left(\frac{\pi D \sin\theta}{\lambda}\right)} \right]^2 \qquad \textbf{(35-8)}$$

Resolution limited by a circular aperture

$$\theta = \frac{1.22\lambda}{D} \qquad \textbf{(35-10)}$$

Principal maxima for diffraction gratings

$$d\sin\theta = m\lambda \qquad m = 0, 1, 2, ... \qquad \textbf{(35-13)}$$

The intensity of a plane-polarized beam transmitted by a polarizer

$$I = I_0 \cos^2\theta \qquad \textbf{(35-21)}$$

Brewster's angle

$$\tan\theta_P = \frac{n_2}{n_1} \qquad \textbf{(35-22)}$$

Radius of a nucleus

$$r \approx \left(1.2\times10^{-15} m\right)\left(A^{\frac{1}{3}}\right) \qquad \textbf{(42-1)}$$

Einstein's equation

$$E = mc^2$$

Constants:

1. Permittivity of free space
   $\varepsilon_0 = 8.85\times10^{-12} \quad C^2 / N\cdot m^2$
2. Charge on an electron
   $e = 1.60\times10^{-19} \quad C$
3. Speed of light in vacuum
   $c = 3.00\times10^{8} \quad m/s$
4. Permeability of free space
   $\mu_0 = 4\pi\times10^{-7}$ T·m/A
5. Unified atomic mass unit
   $1u = 1.6605\times10^{-27} kg = 931.5 MeV/c^2$