NJIT Physics 121 Formula Sheet

Fundamental Constants

Electron: $e = -1.6 \times 10^{-19}$ C, $m_e = 9.11 \times 10^{-31}$ kg
Proton: $m_p = 1.67 \times 10^{-27}$ kg
Electromagnetic constants: $\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/(N{\cdot}m^2)}$
$1/(4\pi\epsilon_0) = k = 9 \times 10^9\ \mathrm{(N{\cdot}m^2)/C^2}$
$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{T{\cdot}m/A}$
Acceleration due to gravity: $g = 9.8\ \mathrm{m/s^2}$

Preliminaries: Vectors, General Mathematics

Vector magnitude: $|\vec{A}| = \sqrt{A_x^2 + A_y^2}$ or $\sqrt{A_x^2 + A_y^2 + A_z^2}$
Vector direction: $\tan\theta = \frac{A_y}{A_x}$
Dot product: $\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z = |\vec{A}||\vec{B}|\cos\theta$
Cross product: $\hat{i}\times\hat{j} = \hat{k} \quad \hat{j}\times\hat{k} = \hat{i} \quad \hat{k}\times\hat{i} = \hat{j}$
$\hat{i}\times\hat{i} = \hat{j}\times\hat{j} = \hat{k}\times\hat{k} = 0$
$\vec{A}\times\vec{B} = (A_yB_z - A_zB_y)\,\hat{i} + (A_zB_x - A_xB_z)\,\hat{j} + (A_xB_y - A_yB_x)\,\hat{k}$
$|\vec{A}\times\vec{B}| = |\vec{A}||\vec{B}|\sin\theta$
Quadratic formula: $ax^2 + bx + c = 0$, $x = \left(-b \pm \sqrt{b^2 - 4ac}\right)/(2a)$
Integrals: $\int dx/x = \ln x$; $\int dx/\sqrt{a^2+x^2} = \ln(x + \sqrt{a^2+x^2})$
$\int dx\left(a^2+x^2\right)^{-\frac{3}{2}} = x/\left(a^2\sqrt{a^2+x^2}\right)$
$\int x\left(a^2+x^2\right)^{-\frac{3}{2}}\ dx = -1/\sqrt{a^2+x^2}$
Circumference: $C = 2\pi R$
Sphere area, volume: $A = 4\pi R^2$, $V = \frac{4}{3}\pi R^3$
Cylinder and cone volume: $V = \pi R^2 h$ (cylinder), $V = \frac{1}{3}\pi R^2 h$ (cone)

Physics 111

Kinematics: $v_f = v_0 + at$
$\Delta x = v_0 t + \frac{1}{2}at^2$
$v_f^2 = v_0^2 + 2a\Delta x$
$v_f + v_0 = 2\Delta x/t$
Newton's Laws: $\vec{F}_{\text{net}} = 0 \longleftrightarrow \vec{v} = \text{constant}$
$\vec{F}_{\text{net}} = m\vec{a}$
$\vec{F}_{12} = -\vec{F}_{21}$
Uniform circular motion $\omega = v/R$, $a_{\text{c}} = v^2/R = \omega^2 R$
Work and power: $W = \int_a^b \vec{F}\cdot d\vec{r}$, $P = W/t = \vec{F}\cdot\vec{v}$
Kinetic energy: $K = \frac{1}{2}mv^2$
Work-Energy Theorem $\Delta K = W_{\text{net}}$
Potential energy (conservative forces): $W_{\text{ab}} = U_{\text{a}} - U_{\text{b}} = -\Delta U$

Chapter 21: Coulomb's Law and the Electric Field

Coulomb's Law: $\vec{F} = \dfrac{1}{4\pi\epsilon_0}\dfrac{|q_1q_2|}{r^2}\hat{r}$
Force on a test charge q_0: $\vec{F} = q_0\vec{E}$
Field of a point charge: $\vec{E} = \dfrac{1}{4\pi\epsilon_0}\dfrac{q}{r^2}\hat{r}$
Charge density: $\lambda = Q/L$ (linear)
$\sigma = Q/A$ (area)
$\rho = Q/V$ (volume)
Field of an infinite line of charge: $E = \dfrac{\lambda}{2\pi\epsilon_0 r}$
Field of an infinite nonconducting plane of charge: $E = \dfrac{\sigma}{2\epsilon_0}$

Chapter 22: Gauss's Law

Flux of a uniform field through a flat surface: $\Phi_E = EA\cos\phi$
Flux of a nonuniform field: $\Phi_E = \oint \vec{E}\cdot d\vec{A}$
Gauss's Law $\oint \vec{E}\cdot d\vec{A} = \dfrac{Q_{\text{enc}}}{\epsilon_0}$
Field at the surface of a conductor: $E = \dfrac{\sigma}{\epsilon_0}$
Solid insulating sphere, radius R, with charge Q distributed uniformly throughout volume: $E = \dfrac{1}{4\pi\epsilon_0}\dfrac{Q}{r^2}$ (outside, $r > R$)
$E = \dfrac{1}{4\pi\epsilon_0}\dfrac{Qr}{R^3}$ (inside, $r < R$)