**Useful constants:**

$\epsilon_0 = 8.85\times10^{-12}\,\frac{C^2}{Nm^2}$
$m_e = 9.11\times10^{-31}kg$
$m_p = 1.67\times10^{-27}kg$
$q_e = e = 1.60\times10^{-19}C$

**Equations of motion for constant acceleration:**

$v_x = v_{0x} + a_x\Delta t$
$v_x^2 = v_{0x}^2 + 2a_x\Delta x$
$\Delta x = v_{0x}\Delta t + \frac{1}{2}a_x\Delta t$
$\Delta x = \frac{1}{2}(v_{0x} + v_x)\,\Delta t$

**Chapter 21**

$\vec{F} = \frac{1}{4\pi\epsilon_0}\frac{|q_1||q_2|}{r^2}\hat{r}$

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

$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{|q_1|}{r^2}\hat{r}$

Electric dipole

$\vec{p} = |q|\vec{d}$
$\vec{\tau} = \vec{p}\times\vec{E}$
$U = -\vec{p}\cdot\vec{E}$

Electric field

$\vec{E} = \frac{1}{4\pi\epsilon_0}\sum_{i=1}\frac{q_i}{r_i^2}\hat{r_i}$

$d\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{dq}{r^2}\hat{r}$

**Chapter 22**

$\Phi_E = \int \vec{E}\cdot d\vec{A}$

Gauss's Law

$\Phi_E = \oint \vec{E}\cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_0}$

**Chapter 23**

Electric Potential energy

$\Delta U = -W$
$W = \int \vec{F}\cdot d\vec{l}$

$U = \frac{q_0}{4\pi\epsilon_0}\sum_i\frac{q_i}{r_i}$

Electric potential

$V = \frac{U}{q_0}$

$V = \frac{1}{4\pi\epsilon_0}\sum_{i=1}\frac{q_i}{r_i}$

$\Delta V = V_b - V_a = -\int_a^b \vec{E}\cdot d\vec{s}$

$\vec{E} = -\vec{\nabla}V$

Capacitance

$C = \frac{Q}{V}$

Parallel-plate capacitor

$C = \frac{A}{d}\epsilon$

Capacitor energy

$$U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}QV = \frac{1}{2}CV^2$$

Dielectric constant

$$K = \frac{\epsilon}{\epsilon_0} = \frac{E_0}{E} = \frac{V_0}{V} = \frac{C_0}{C}$$