The following equations may be useful for the SP212 Final Exam.

Equation	Name	What it does	Serway
$\sum \mathbf{F} = m\mathbf{a}$	Newton's Second Law	Relates the acceleration of a body to the forces acting on it.	p. 104
$K \equiv \frac{1}{2}mv^2$	Definition of Kinetic Energy	Relates the energy of a body to its velocity.	p. 174
$\mathbf{F}_{12} = k_e \frac{\lvert q_1 \rvert \lvert q_2 \rvert}{r^2}\hat{\mathbf{r}}$	Coulomb's Law	Identifies the electric force between two charged particles.	p. 647
$\mathbf{E} \equiv \frac{\mathbf{F}_e}{q_0}$	Definition of Electric Field	Defines the electric field as the ratio of the electric force experienced by a charged body to the charge on that body.	p. 651
$\mathbf{E} = k_e \frac{q}{r^2}\hat{\mathbf{r}}$	Electric Field Due to Point Charge	Identifies the electric field due to a point charge at distance r.	p. 652
$\mathbf{E} = k_e \int \frac{dq}{r^2}\hat{\mathbf{r}}$	Electric Field Due to Continuous Charge Distribution	Identifies the electric field due to a continuous distribution of electric charge.	p. 647
$\Phi_E \equiv \int_{\text{surface}} \mathbf{E} \cdot d\mathbf{A}$	Definition of Electric Flux	Identifies the electric flux through a surface.	p. 674
$\Phi_E = \oint \mathbf{E} \cdot d\mathbf{A} = \frac{q_{\text{in}}}{\epsilon_0}$	Gauss's Law	Relates the electric flux through a closed surface to the total charge contained within the surface.	p. 677
$\Delta V \equiv \frac{\Delta U}{q_0} = \int_{\text{a}}^{\text{b}} \mathbf{E} \cdot d\mathbf{s}$	Potential Difference	Relates the potential difference between two points to (1) the potential energy gained (or lost) by a particle accelerated through that potential difference, and (2) the electric field in that area.	p. 693

Equation	Name	What it does	Serway
$V = k_e \frac{q}{r}$	Electric Potential Due to Point Charge	Identifies the electric potential due to a point charge.	p. 698
$U = k_e \sum_{i \neq j} \frac{q_i q_j}{r_{ij}}$	Electrical potential energy due to a system of point charges.	Identifies the electrical potential energy due to a system of point charges.	p. 699
$E = -\nabla V$	Electric Field Due to Given Electric Potential	Identifies the electric field as the negative gradient of the scalar electric potential.	p. 702
$V = k_e \int \frac{dq}{r}$	Electric Potential Due to Continuous Charge Distribution	Identifies the electric potential due to a continuous charge distribution.	p. 703
$C \equiv \frac{Q}{\Delta V}$	Definition of Capactiance	Relates the charge on a capacitor to the voltage applied.	p. 723
$C_{\text{eq}} = C_1 + C_2 + C_3 + \cdots$	Capacitors in Parallel	Calculates equivalent capacitance for capacitors connected in parallel.	p. 728
$\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots$	Capacitors in Series	Calculates equivalent capacitance for capacitors connected in series.	p. 730
$U = \frac{Q^2}{2C} = \frac{1}{2} Q \Delta V = \frac{1}{2} C (\Delta V)^2$	Energy Stored in a Charged Capacitor	Relates the energy stored in a charged capacitor to the total stored charge Q, the voltage drop ΔV across the capacitor, and the capacitance C.	p. 732
$u_E = \frac{1}{2} \epsilon_0 E^2$	Energy Stored in Electric Field	Relates the energy stored in an electric field to field strength E.	p. 733

Equation	Name	What it does	Serway
$C = \kappa C_0$	Capacitance with Dielectric	Relates the capacitance of a capacitor with dielectric to capacitance of same capacitor without dielectric.	p. 735
$C = \kappa \frac{\epsilon_0 A}{d}$	Parallel Plate Capacitor	Identifies the capacitance of a parallel plate capacitor with dielectric of dielectric constant κ, plate area A and plate separation d.	p. 736
$p \equiv 2aq$	Electric Dipole Moment	Identifies the magnitude of the electric dipole moment due to dipole composed of charges $+q$ and $-q$ separated by distance $2a$.	p. 738
$\boldsymbol{\tau} = \mathbf{p} \times \mathbf{E}$	Torque on a Dipole	Identifies the torque on an electric dipole in an external electric field.	p. 738
$U = -\mathbf{p} \cdot \mathbf{E}$	Energy of Dipole-Field System	Identifies the potential energy of an electric dipole-external electric field system.	p. 739
$I \equiv \frac{dQ}{dt}$	Definition of Electric Current	Defines electric current as the flow of charge.	p. 753
$I_{\text{avg}} = \frac{\Delta Q}{\Delta t} = nqv_d A$	Current in a Conductor	Relates the average current to the cross-sectional area A of the conductor and the number n, charge q, and drift velocity v_d of current carriers.	p. 754
$J \equiv \frac{I}{A} = nqv_d$	Definition of Current Density	Defines current density as ratio of current I to cross-sectional area A of conductor.	p. 756

Equation	Name	What it does	Serway
$J = \sigma E = \frac{1}{\rho} E$	Current Density in Terms of Electric Field	Relates current density to electric field in a conductor via conductivity σ and resistivity ρ.	p. 756
$u_E = \frac{1}{2}\epsilon_0 E^2$	Energy Stored in Electric Field	Relates the energy stored in an electric field to field strength E.	p. 733
$R = \rho \frac{l}{A}$	Resistance (uniform material)	Relates the resistance of a uniform material of resistivity ρ to its length l and cross-sectional area A.	p. 757
$R \equiv \frac{\Delta V}{I}$	Definition of Resistance	Defines the resistance in a circuit as the ratio of applied voltage ΔV to resulting current I.	p. 757
$\rho = \rho_0[1 + \alpha(T - T_0)]$	Temperature Dependence of Resistivity	Relates resistivity to temperature by means of a temperature coefficient of resistivity α.	p. 762
$\mathscr{P} = I\Delta V = I^2 R = \frac{(\Delta V)^2}{R}$	Definition of Electrical Power	Relates electrical power to voltage, resistance, and current.	p. 764
$\mathcal{E} = IR + Ir$	Definition of emf	Establishes the sum of resistance R and internal (battery) resistance r as the constant of proportionality between an applied emf $\mathcal{E}$ and the resulting current I in a circuit.	p. 776
$R_{\text{eq}} = R_1 + R_2 + R_3 + \cdots$	Resistors in Series	Calculates equivalent resistance for resistors connected in series.	p. 779
$\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$	Resistors in Parallel	Calculates equivalent resistance for resistors connected in parallel.	p. 781

Equation	Name	What it does	Serway
$\sum_{\text{junc}} I = 0$	Kirchhoff's Junction Rule	Relates the currents entering a circuit junction to the currents leaving that junction.	p. 785
$\sum_{\text{loop}} \Delta V = 0$	Kirchhoff's Loop Rule	Relates the potential drops and climbs around a closed circuit loop.	p. 785
$q(t) = C\mathcal{E}(1 - e^{-t/RC})$	Charge on a Charging Capacitor	Gives the charge on a charging capacitor in an RC-circuit as a function of time.	p. 790
$I(t) = \frac{\mathcal{E}}{R}e^{-t/RC}$	Current in RC-Circuit (Charging)	Gives the current through the resistor during the charging of an RC-circuit as a function of time.	p. 790
$\tau = RC$	Time Constant	Identifies the time constant of an RC-circuit as the product of resistance R and capacitance C.	p. 790
$q(t) = Qe^{-t/RC}$	Charge on a Discharging Capacitor	Gives the charge on a discharging capacitor in an RC-circuit as a function of time.	p. 791
$I(t) = -\frac{Q}{RC}e^{-t/RC}$	Current in RC-Circuit (Discharging)	Gives the current through the resistor during the discharging of an RC-circuit as a function of time.	p. 791
$r = \frac{mv}{qB}$	Radius of Circular Path (charged particle in magnetic field)	Calculates the radius of the circular path traversed by a particle of charge q and mass m with perpendicular speed component v in a magnetic field of strength B.	p. 813
$\mathbf{F} = q\mathbf{E} + q\mathbf{v} \times \mathbf{B}$	Lorentz Force Law	Relates the force on a charged particle to its exposure to an electric field and its motion through a magnetic field.	p. 816

Equation	Name	What it does	Serway
$\mathbf{F}_B = I\hat{\mathbf{L}} \times \mathbf{B}$	Magnetic Force (on a segment of current-carrying wire)	Relates the force felt by a current-carrying wire of length $\lvert\hat{\mathbf{L}}\rvert$ to the magnetic field to which the wire is exposed.	p. 820
$\boldsymbol{\mu} = I\mathbf{A}$	Magnetic Dipole Moment of a Current Loop	Defines the magnetic dipole moment of a current-carrying conductor loop.	p. 823
$\boldsymbol{\tau} = \boldsymbol{\mu} \times \mathbf{B}$	Torque on a Magnetic Moment	Identifies the torque on a magnetic moment in a magnetic field.	p. 823
$U = -\boldsymbol{\mu} \cdot \mathbf{B}$	Potential Energy of Magnetic Moment	Gives the potential energy of a magnetic moment $\boldsymbol{\mu}$ in a magnetic field $\mathbf{B}$.	p. 823
$d\mathbf{B} = \frac{\mu_0}{4\pi}\frac{I\,d\mathbf{s} \times \hat{\mathbf{r}}}{r^2}$	Biot-Savart Law	Allows the calculation of the magnetic field due to an arbitrary source.	p. 838
$\frac{F_B}{l} = \frac{\mu_0 I_1 I_2}{2\pi a}$	Magnetic Force Between Current-Carrying Wires	Identifies the magnetic force between two current-carrying wires of length l separated by distance a.	p. 843
$\oint \mathbf{B} \cdot d\mathbf{s} = \mu_0 I$	Ampère's Law	Relates a magnetic field to its source.	p. 845
$B = \frac{\mu_0 I}{2\pi r}$	Magnetic Field (long current-carrying wire)	Relates the magnetic field of an infinitely long current-carrying wire to its current I and the distance r from the wire.	p. 847
$B = \frac{\mu_0 N I}{2\pi r}$	Magnetic Field (torus of toroid)	Relates the magnetic field inside the torus of a toroid to current I, number of turns N, and distance r from center of toroid.	p. 848

Equation	Name	What it does	Serway
$B = \mu_0 \frac{N}{l} I = \mu_0 n I$	Magnetic Field Inside a Solenoid	Relates the strength of the magnetic field inside a solenoid to current I and number of turns N.	p. 849
$\Phi_B \equiv \int \mathbf{B} \cdot d\mathbf{A}$	Definition of Magnetic Flux	Defines magnetic flux.	p. 850
$\oint \mathbf{B} \cdot d\mathbf{A} = 0$	Gauss's Law in Magnetism	Repudiates the existence of magnetic monopoles.	p. 852
$\mathcal{E} = -\frac{d\Phi_B}{dt}$	Faraday's Law of Induction	Relates the emf induced in a circuit to the changing magnetic flux source of the induced electric field responsible for the emf.	p. 869
$\mathcal{E} = -Blv$	Motional Emf (laterally translating conductor)	Relates the emf induced in a laterally translating conductor segment of length l to the magnetic field through which it is moving at speed v.	p. 872
$\oint \mathbf{E} \cdot d\mathbf{s} = -\frac{d\Phi_B}{dt}$	Faraday's Law	Relates an induced electric field to its changing magnetic flux source.	p. 879
$\mathcal{E} = NAB\omega \sin \omega t$	Emf (coil rotating in magnetic field)	Relates the emf in a rotating coil of N turns and cross-sectional area A to its angular speed ω about its diameter in a magnetic field.	p. 881
$\mathcal{E}_L = -L\frac{dI}{dt}$	Self-Induced Emf	Expresses the proportionality of self-induced emf to the time rate of change of current in a circuit.	p. 898
$L = \frac{N\Phi_B}{I}$	Inductance of an N-Turn Coil	Relates inductance L of an N-turn coil to its intrinsic current I and magnetic flux Φ_B.	p. 898

Equation	Name	What it does	Serway
$L = \mu_0 \frac{N^2}{l} A$	Inductance of a Solenoid	Relates the inductance L of a solenoid to its length l, cross-sectional area A, and number of turns N.	p. 899
$I = \frac{\mathcal{E}}{R}\left(1 - e^{-t/\tau}\right)$	Increasing Current in an RL-Circuit	Relates the increasing current in an RL-circuit to applied emf $\mathcal{E}$, resistance R, and inductance L.	p. 901
$\tau = \frac{L}{R}$	Time Constant of RL-Circuit	Identifies the time constant τ of an RL-circuit as the ratio of inductance L and resistance R.	p. 901
$I = \frac{\mathcal{E}}{R} e^{-t/\tau}$	Decreasing Current in an RL-Circuit	Relates the decreasing current in an RL-circuit to initial emf $\mathcal{E}$, resistance R, and inductance L.	p. 901
$U = \frac{1}{2} L I^2$	Energy Stored in an Inductor	Relates the energy stored in an inductor to inductance L and current I.	p. 903
$u_B = \frac{U}{V} = \frac{B^2}{2\mu_0}$	Magnetic Energy Density	Relates the energy density of a magnetic field to the field strength B.	p. 904
$M_{12} = \frac{N_2 \Phi_{12}}{I_1}$	Definition of Mutual Inductance	Defines the mutual inductance of a coil of N_2 turns with respect to an adjacent coil carrying current I_1.	p. 906
$\mathcal{E}_2 = -M \frac{dI_1}{dt}$	Mutually Induced Emf	Relates the emf $\mathcal{E}_2$ induced in a coil by a changing current I_1 in an adjacent coil.	p. 906
$Q = Q_{\text{max}} \cos(\omega t + \phi)$	Charge in an LC-Circuit	Gives the charge Q on the capacitor in an LC-circuit as a function of time.	p. 909

Equation	Name	What it does	Serway
$\omega = \frac{1}{\sqrt{LC}}$	Angular Frequency of Oscillation in an LC-Circuit	Identifies the angular frequency of oscillation in an LC-circuit as the inverse square root of the product of inductance L and capacitance C.	p. 909
$I = -\omega Q_{\text{max}} \sin(\omega t - \phi)$	Current in an LC-Circuit	Gives the current I in an LC-circuit as a function of time.	p. 909
$Q = Q_{\text{max}} e^{-Rt/2L} \cos \omega_d t$	Charge in an RLC-Circuit	Gives the charge Q on the capacitor in an RLC-circuit as a function of time.	p. 913
$\omega_d = \sqrt{\frac{1}{LC} - \left(\frac{R}{2L}\right)^2}$	Angular Frequency of RLC-Circuit	Identifies the angular frequency ω_d of RLC-circuit (damped oscillator).	p. 901
$I_d \equiv \epsilon_0 \frac{d\Phi_E}{dt}$	Definition of Displacement Current	Defines displacement current in terms of electric flux through a surface.	p. 953
$\oint \mathbf{B} \cdot d\mathbf{s} = \mu_0 I + \epsilon_0 \mu_0 \frac{d\Phi_E}{dt}$	Ampère-Maxwell Law	Relates the magnetic field to its current and displacement current sources.	p. 954
$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$	Speed of Electromagnetic Waves	Identifies the speed of light.	p. 959
$E = E_{\text{max}} \cos(kx - \omega t)$	Sinusoidal Electric Wave	Gives the functional form of an electric wave.	p. 959
$B = B_{\text{max}} \cos(kx - \omega t)$	Sinusoidal Magnetic Wave	Gives the functional form of a magnetic wave.	p. 959

Equation	Name	What it does	Serway
$\frac{\omega}{k} = \lambda f = c$	Light Wave Properties	Relates angular frequency ω, wavenumber k, wavelength λ, frequency f, and speed c.	p. 959
$\mathbf{S} \equiv \frac{1}{\mu_0}\mathbf{E} \times \mathbf{B}$	Definition of Poynting Vector	Defines the Poynting vector $\mathbf{S}$ in terms of electric and magnetic fields.	p. 961
$I = S_{\text{avg}} = \frac{E_{\text{max}}B_{\text{max}}}{2\mu_0} = \frac{E_{\text{max}}^2}{2\mu_0 c} = \frac{cB_{\text{max}}^2}{2\mu_0}$	Intensity of EM Wave	Relates the intensity of an electromagnetic wave to its component electric and magnetic field strengths.	p. 961
$I = S_{\text{avg}} = cu_{\text{avg}}$	Wave Intensity in terms of Energy Density	Identifies the intensity I of an electromagnetic wave as proportional to its average energy density u_{avg}.	p. 962
$I = \frac{\mathscr{P}_{\text{avg}}}{4\pi r^2}$	Intensity of Wave from Point Source	Relates the intensity of a wave from a point source to the average power of the wave and distance from source.	p. 963
$P = \frac{S}{c}$	Radiation Pressure (perfectly absorbing surface)	Identifies the radiation pressure P on a perfectly absorbing surface exposed to an electromagnetic wave of energy flow rate S.	p. 964
$P = \frac{2S}{c}$	Radiation Pressure (perfectly reflecting surface)	Identifies the radiation pressure P on a perfectly reflecting surface exposed to an electromagnetic wave of energy flow rate S.	p. 964
$\theta_1' = \theta_1$	Law of Reflection	Relates angle of reflection θ_1' to angle of incidence θ_1.	p. 982

Equation	Name	What it does	Serway
$n \equiv \frac{c}{v} = \frac{\lambda}{\lambda_n}$	Definition of Index of Refraction	Defines index of refraction n as the ratio of the speed of light in a vacuum c to the speed of light v in a particular medium. (Also expressed as ratio of wavelength λ of light in vacuum to wavelength λ_n of light in medium.)	p. 986
$n_1 \sin\theta_1 = n_2 \sin\theta_2$	Snell's Law	Relates the angle of incidence θ_1 to the angle of refraction θ_2.	p. 987
$\sin\theta_c = \frac{n_2}{n_1} \quad (n_2 < n_1)$	Critical Angle of Total Internal Reflection	Relates the critical angle θ_c to the indices of refraction of two media at a boundary.	p. 993
$M \equiv \frac{h'}{h} = -\frac{q}{p}$	Definition of Magnification	Defines magnification M as ratio of image height h' to object height h. (Also expressed as negative ratio of image distance q to object distance p.	p. 1009
$\frac{1}{p} + \frac{1}{q} = \frac{1}{f} = \frac{R}{2}$	Mirror Equation	Relates object distance p, image distance q, focal length f, and radius of curvature R for spherical mirrors.	p. 1012
$\frac{n_1}{p} + \frac{n_2}{q} = \frac{n_2 - n_1}{R}$	Refracting Surface	Relates indices of refraction n_1 and n_2 at a boundary, object distance p, image distance q, and radius of curvature R of a refracting surface.	p. 1018
$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$	Lens-Makers' Equation	Relates the focal length f, index of refraction n, and radii of curvature R_1 and R_2 of a spherical lens.	p. 1022
$\frac{1}{p} + \frac{1}{q} = \frac{1}{q}$	Thin Lens Equation	Relates object distance p, image distance q, focal length f of a thin lens.	p. 993

Equation	Name	What it does	Serway
$d \sin\theta_{\text{bright}} = m\lambda \quad (m = 0, \pm 1, \pm 2, \ldots)$	Conditions for Constructive Interference (angular)	Identifies the angles θ_{bright} at which light of wavelength λ emerging from two slits separated by distance d constructively interferes.	p. 1054
$d \sin\theta_{\text{dark}} = \left(m + \frac{1}{2}\right)\lambda \quad (m = 0, \pm 1, \pm 2, \ldots)$	Conditions for Destructive Interference (angular)	Identifies the angles θ_{dark} at which light of wavelength λ emerging from two slits separated by distance d destructively interferes.	p. 1054
$y_{\text{bright}} = m\frac{\lambda L}{d} \quad (m = 0, \pm 1, \pm 2, \ldots)$	Conditions for Constructive Interference (linear)	Identifies the locations y_{bright} relative to centerline of length L at which light of wavelength λ emerging from two slits separated by distance d constructively interferes to form bright fringe.	p. 1054
$y_{\text{dark}} = \left(m + \frac{1}{2}\right)\frac{\lambda L}{d} \quad (m = 0, \pm 1, \pm 2, \ldots)$	Conditions for Destructive Interference (linear)	Identifies the locations y_{dark} relative to centerline of length L at which light of wavelength λ emerging from two slits separated by distance d destructively interferes to form dark fringe.	p. 1054
$I = I_{\text{max}} \cos^2\left(\frac{\pi d \sin\theta}{\lambda}\right)$	Double Slit Intensity	Identifies the intensity I of fringe pattern from double slit as function of slit separation d, angle θ of emerging light, and wavelength λ.	p. 1058
$2nt = \left(m + \frac{1}{2}\right)\lambda \quad (m = 0, 1, 2, \ldots)$	Thin Film Constructive Interference	Identifies the thickness t for which constructive interference of light of wavelength λ is observed in a thin film of refractive index n.	p. 1060

Equation	Name	What it does	Serway
$2nt = m\lambda \quad (m = 0, 1, 2, \ldots)$	Thin Film Destructive Interference	Identifies the thickness t for which destructive interference of light of wavelength λ is observed in a thin film of refractive index n.	p. 1060
$\sin\theta_{\text{dark}} = m\frac{\lambda}{a} \quad (m = \pm1, \pm2, \pm3, \ldots)$	Single Slit Destructive Interference	Identifies the angles θ_{dark} at which light of wavelength λ emerging from a single slit of width a destructively interferes.	p. 1080
$\theta_{\text{min}} = 1.22\frac{\lambda}{D}$	Limiting Angle of Resolution for a Circular Aperture	Identifies the limiting angle of resolution θ_{min} for a circular aperture of diameter D and light of wavelength λ.	p. 1084
$I = I_{\text{max}}\cos^2\theta$	Malus's Law	Identifies the intensity I of polarized light of initial intensity I_{max} after passing through a second polarizer oriented at angle θ to the first.	p. 1094
$\tan\theta_p = \frac{n_2}{n_1}$	Brewster's Law	Identifies the angle of incidence θ_p for which reflected light at an interface of media of refractive indices n_1 and n_2 will be completely polarized.	p. 1095