Unit 1:

- topic 1.1
  - describe charges & their interactions
  - explain behavior of neutral objects next to charges
  - calculate electrostatic force & other unknown quantities
  - determine paths of objects
  - coulomb's law
    - $F_E = \frac{1}{4\pi\varepsilon_0}\left|\frac{q_1 q_2}{r^2}\right|$
- topic 1.2
  - determine the direction calculate the electric field
  - equations
    - $E = \frac{F_E}{q}$
    - $F_E = \frac{1}{4\pi\varepsilon_0}\left|\frac{q_1 q_2}{r^2}\right|$
  - sketch & interpret electric field diagrams
  - know trajectory of particles in a uniform electric field
- topic 1.3
  - calculate electric potential at certain points
  - equations
    - $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$
    - $V = \frac{1}{4\pi\varepsilon_0}\sum\frac{q_i}{r_i}$
    - $\Delta U = q\Delta U$
    - $U_E = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$
    - $\Delta V = V_b - V_a = -\int_a^b E\,dr$
    - $E_x = \frac{-dV}{dx}$
  - calculate electrostatic potential energy, potential differences & work done
  - understand equipotential lines
  - use integration to calculate a potential difference

- topic 1.4
  - calculate electric flux through an area when the field is perpendicular
  - Gauss's law
    - $\phi = \int E\,dA$
  - equations
    - $\int E\,dA = \frac{q}{\varepsilon_0}$
    - $Q_+ = \int \rho(r)\,dV$
    - $\int E\,dA = \frac{Q}{\varepsilon_0} = \Phi_E$
- topic 1.5
  - derive expressions for the electric field using calculus
  - equations
    - $dE = \frac{1}{4\pi\varepsilon_0}\frac{dq}{r^2}r$
    - $V = \frac{1}{4\pi\varepsilon_0}\int\frac{dq}{r}$
  - describe an electric field as a function of distance
  - use integration & superposition to derive electric potential
  - identify regions of higher vs lower electric potential

Unit 2

- topic 2.1
  - extra charge on a conductor resides on it's surface
  - no electric field inside of a conductor
  - a conducting surface is equipotential
  - calculate electric potential on charged surfaces
  - describe process of charging a conductor through induction
  - charged objects attract neutral conductors
  - electrostatic shielding: surrounding an area by a conductor to diminish an electric field
- topic 2.2
  - calculate charge, potential difference or capacitance
  - equations
    - $C = \frac{Q}{\Delta V}$
    - $U_E = \frac{1}{2}C(\Delta V)^2$
  - explain how a charged capacitor converts energy to forms
  - relate the electric field to capacitor plates
- topic 2.3
  - insulator's molecules polarize when placed in a field
  - inserting dielectrics reduces potential differences
  - $C = \frac{K\varepsilon_0 A}{d}$
  - calculate quantities when energy, charge etc. change

Unit 3:

- topic 3.1
  - relate direction of current to rate of flow of positive/negative charge
  - compare resistances of different materials
  - describe properties of conductors & drift velocity
  - equations
    - $I = \frac{dQ}{dt}$
    - $I = \frac{\Delta V}{R}$
    - $R = \frac{\rho l}{A}$
    - $E = \rho J$
    - $I = Nev_d A$
  - use Ohm's law to relate potential difference, current & resistance
- topic 3.2
  - calculate rate of heat production in resistors
  - equations
    - $P = I\Delta V$
    - $V = IR$
- topic 3.3
  - calculate terminal voltage & internal resistance
  - use Kirchhoff's Rules to calculate current, resistance or potential difference
  - use ammeters & voltmeters appropriately
  - identify & describe series or parallel resistors
  - calculate equivalent resistances for different arrangements
  - equations
    - $R_s = \sum R_i$
    - $\frac{1}{R_p} = \sum\frac{1}{R_i}$

- topic 3.4
  - calculate equivalent capacitance & potential differences in series & parallel circuits
  - equations
    - $\frac{1}{C_s} = \sum\frac{1}{C_i}$
    - $C_p = \sum C_i$
    - $\tau = RC$
    - $U_E = \frac{1}{2}C(\Delta V)^2$
  - describe voltage & current behavior over time
  - describe energy transfer

Unit 4:

- topic 4.1
  - calculate magnitude & direction of magnetic force
  - derive an expression for radius of a circular path
  - magnetic force only works on a moving charge
  - equations
    - $F_B = q(V \times B)$
  - describe the motion of a charged particle through a magnetic field
- topic 4.2
  - describe direction of magnetic force on a current-carrying wire
  - equations
    - $F_B = \int I(dl \times B)$
  - torques can be a result of wire loops in magnetic fields
- topic 4.3
  - calculate magnitude & the direction of the magnetic field near a wire
  - equations
    - $B = \frac{\mu_0 I}{2\pi r} = \mu_0 n I$
  - calculate force of attraction or repulsion between wires
- topic 4.4
  - Biot-Savart Law
    - $dB = \frac{\mu_0}{4\pi} \frac{I(dl \times r)}{r^2}$
  - Ampère's Law
    - $\int B \cdot dl = \mu_0 I$
  - derive expressions for the ideal magnetic field in a solenoid

Unit 5:

- topic 5.1
  - calculate magnetic flux due to wires in uniform & non-uniform fields
  - equations
    - $\phi = \int B \cdot dA$
    - $\varepsilon_i = -N \frac{d\Phi_B}{dt}$
  - determine direction of current in a loop
  - calculate the magnitude of induced current/emf
  - Lenz's Law: flux opposes change in field
  - determine if force or torque exists on a loop in a field
  - calculate terminal velocity
- topic 5.2
  - equations
    - $\varepsilon_i = -L\frac{dI}{dt}$
    - $U_L = \frac{1}{2}LI^2$
  - calculate stored energy in an inductor
  - calculate initial transient & final steady currents
  - calculate maximum current
  - derive an equation for a simple LR circuit
- topic 5.3
  - explain how a changing magnetic field can induce an electric field
  - Maxwell's Laws: describe the relationship between magnetic & electric fields