Charge per unit Area: $[C/m^2]$

$$= \frac{q}{A}$$

= charge per unit area $[C/m^2]$
q = charge $[C]$
A = area $[m^2]$

Energy Density: (in a vacuum) $[J/m^3]$

$$u = \tfrac{1}{2}\epsilon_0 E^2$$

u = energy per unit volume $[J/m^3]$
ϵ_0 = permittivity of free space $8.85 \times 10^{-12}\ C^2/N{\cdot}m^2$
E = energy $[J]$

Capacitors in Series:

$$\frac{1}{C_{eff}} = \frac{1}{C_1} + \frac{1}{C_2} \ldots$$

Capacitors in Parallel:

$$C_{eff} = C_1 + C_2 \ldots$$

Capacitors connected in series all have the same charge q. For parallel capacitors the total q is equal to the sum of the charge on each capacitor.

Time Constant: [seconds]

$$\tau = RC$$

= time it takes the capacitor to reach 63.2% of its maximum charge [seconds]
R = series resistance [ohms Ω]
C = capacitance [farads F]

Charge or Voltage after t Seconds: [coulombs C]

charging:

$$q = Q\left(1 - e^{-t/}\right)$$
$$V = V_S\left(1 - e^{-t/}\right)$$

discharging:

$$q = Qe^{-t/}$$
$$V = V_S\, e^{-t/}$$

q = charge after t seconds [coulombs C]
Q = maximum charge [coulombs C] $Q = CV$
e = natural log
t = time [seconds]
= time constant RC [seconds]
V = volts $[V]$
V_S = supply volts $[V]$

[Natural Log: when $e^b = x$, $\ln x = b$]

Drift Speed:

$$I = \frac{\Delta Q}{\Delta t} = \left(nqv_d A\right)$$

ΔQ = # of carriers × charge/carrier
Δt = time in seconds
n = # of carriers
q = charge on each carrier
v_d = drift speed in meters/second
A = cross-sectional area in meters^2

RESISTANCE

Emf: A voltage source which can provide continuous current [volts]

$$\varepsilon = IR + Ir$$

ε = emf open-circuit voltage of the battery
I = current [amps]
R = load resistance [ohms]
r = internal battery resistance [ohms]

Resistivity: [Ohm Meters]

$$= \frac{E}{J}$$
$$= \frac{RA}{L}$$

= resistivity [$\cdot m$]
E = electric field $[N/C]$
J = current density $[A/m^2]$
R = resistance [ohms]
A = area $[m^2]$
L = length of conductor $[m]$

Variation of Resistance with Temperature:

$$- {}_0 = {}_0\ (T - T_0)$$

= resistivity [$\cdot m$]
= reference resistivity [$\cdot m$]
= temperature coefficient of resistivity $[K^{-1}]$
T_0 = reference temperature
$T - T_0$ = temperature difference [K or °C]

CURRENT

Current Density: $[A/m^2]$

$$I = \int \mathbf{J} \cdot d\mathbf{A}$$

if current is uniform and parallel to $d\mathbf{A}$, then: $I = JA$

$$J = (ne)V_d$$

I = current $[A]$
J = current density $[A/m^2]$
A = area $[m^2]$
L = length of conductor $[m]$
e = charge per carrier
ne = carrier charge density $[C/m^3]$
V_d = drift speed $[m/s]$

Rate of Change of Chemical Energy in a Battery:

$$P = I$$

P = power $[W]$
I = current $[A]$
= emf potential $[V]$

Kirchhoff's Rules

1. The sum of the currents entering a junctions is equal to the sum of the currents leaving the junction.
2. The sum of the potential differences across all the elements around a closed loop must be zero.

Evaluating Circuits Using Kirchhoff's Rules

1. Assign current variables and direction of flow to all branches of the circuit. If your choice of direction is incorrect, the result will be a negative number. Derive equation(s) for these currents based on the rule that currents entering a junction equal currents exiting the junction.
2. Apply Kirchhoff's loop rule in creating equations for different current paths in the circuit. For a current path beginning and ending at the same point, the sum of voltage drops/gains is zero. When evaluating a loop in the direction of current flow, resistances will cause drops (negatives); voltage sources will cause rises (positives) provided they are crossed negative to positive—otherwise they will be drops as well.
3. The number of equations should equal the number of variables. Solve the equations simultaneously.

Properties of electric charge and mass or comparision of the properties of electric charge and mass

Electric Charge	Mass
1.) Electric charge may be positive or negative.	1.) Mass of the body is always a positive quantity.
2.) Charge is quantised.	2.) Mass of a body is not quantised.
3.) Charge is always conserved.	3.) Mass can be changed into energy.
4.) Charge on a body is not effected by the velocity of the body.	4.) Mass of the body change with velocity of the body.
5.) Force between charge may be attractive or repulsive.	5.) Force between mass is always attractive.
6.) It play important roll in electricity.	6.) It has an Important roll in gravitation.