Electron = $-1.602\ 19 \times 10^{-19}$ C = 9.11×10^{-31} kg
Proton = $1.602\ 19 \times 10^{-19}$ C = 1.67×10^{-27} kg
Neutron = 0 C = 1.67×10^{-27} kg
6.022×10^{23} atoms in one atomic mass unit
e is the elementary charge: $1.602\ 19 \times 10^{-19}$ C

Addition of Multiple Vectors:

$\vec{R} = \vec{A} + \vec{B} + \vec{C}$ Resultant = Sum of the vectors

$\vec{R}_x = \vec{A}_x + \vec{B}_x + \vec{C}_x$ *x*-component $A_x = A\cos\theta$

$\vec{R}_y = \vec{A}_y + \vec{B}_y + \vec{C}_y$ *y*-component $A_y = A\sin\theta$

$R = \sqrt{R_x^{\,2} + R_y^{\,2}}$ Magnitude (length) of R

$\theta_R = \tan^{-1}\dfrac{R_y}{R_x}$ *or* $\tan\theta_R = \dfrac{R_y}{R_x}$ Angle of the resultant

ELECTRIC CHARGES AND FIELDS

Coulomb's Law: [Newtons N]

$$F = k\frac{|q_1||q_2|}{r^2}$$

where: F = force on one charge by the other[N]
$k = 8.99 \times 10^9$ [$N{\cdot}m^2/C^2$]
q_1 = charge [C]
q_2 = charge [C]
r = distance [m]

Electric Field: [Newtons/Coulomb or Volts/Meter]

$$E = k\frac{|q|}{r^2} = \frac{|F|}{|q|}$$

where: E = electric field [N/C or V/m]
$k = 8.99 \times 10^9$ [$N{\cdot}m^2/C^2$]
q = charge [C]
r = distance [m]
F = force

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

$$\vec{\boldsymbol{E}} = k\int_Q \frac{dq}{r^2}\,\hat{\boldsymbol{r}} = \frac{1}{4\pi\varepsilon_0}\int_Q \frac{dq}{r^2}\,\hat{\boldsymbol{r}}$$

Flux: the rate of flow (of an electric field) [$N{\cdot}m^2/C$]

$$\Phi = \oint \mathbf{E}\cdot d\mathbf{A}$$
$$= \int E(\cos\theta)dA$$

$\mathbf{\Phi}$ is the rate of flow of an electric field [$N{\cdot}m^2/C$]
$\oint$ integral over a closed surface
$\mathbf{E}$ is the electric field vector [N/C]
$\mathbf{A}$ is the area vector [m^2] pointing outward normal to the surface.

Gauss' law: $$\Phi_E = \oint_S \vec{\boldsymbol{E}}\cdot d\vec{\boldsymbol{A}} = \frac{Q_{enc}}{\varepsilon_0}$$

Electric field calculations:

Charge distribution	Electric field E (magnitude)
Point charge	$E = \dfrac{k\,\lvert Q\rvert}{r^2}$
Charged ring of radius a (along its axis, which is taken to be the X-axis)	$E = \dfrac{k\,\lvert Qx\rvert}{(x^2+a^2)^{3/2}}$
Charged disc of radius a (along its axis, which is taken to be the X-axis)	$E = \dfrac{\lvert\sigma\rvert}{2\varepsilon_0}\left[1 - \dfrac{\lvert x\rvert}{\sqrt{x^2+a^2}}\right]$
Infinite non-conducting charged sheet perpendicular to the X-axis	$E = \dfrac{\lvert\sigma\rvert}{2\varepsilon_0}$
Infinite line with uniform charge distribution	$E = \dfrac{\lvert\lambda\rvert}{2\pi\varepsilon_0 r} = \dfrac{2k\,\lvert\lambda\rvert}{r}$
Sphere of radius a with uniform charge distribution	$E = \dfrac{k\,\lvert Q\rvert}{r^2}$ $r \geq a$ $E = \dfrac{k\,\lvert Q\rvert\, r}{a^3}$ $r \leq a$

Electric potential: $V = k\int_Q \frac{dq}{r} = \frac{1}{4\pi\varepsilon_0}\int_Q \frac{dq}{r}$ relative to $V = 0$ at $r \to \infty$

Relationship between $\vec{\boldsymbol{E}}$ and V: $V_a - V_b = \int_a^b \vec{\boldsymbol{E}} \cdot d\vec{\boldsymbol{l}}$ $\qquad E_i = -\frac{\partial V}{\partial x_i}$

Work done by the field in moving a charge q from a to b : $W_{ab} = U_a - U_b = q\,(V_a - V_b)$

Potential energy of a system of point charges: $U = \sum_{i<j} \frac{kQ_iQ_j}{r_{ij}}$

Work and Potential:

$\Delta U = U_f - U_i = -W$

$U = -W_\infty$

$W = \mathbf{F} \cdot \mathbf{d} = Fd\cos\theta$

$W = q\int_i^f \mathbf{E} \cdot d\mathbf{s}$

$\Delta V = V_f - V_i = -\frac{W}{q}$

$V = -\int_i^f \mathbf{E} \cdot d\mathbf{s}$

U = electric potential energy [J]
W = work done on a particle by a field [J]
W_∞ = work done on a particle brought from infinity (zero potential) to its present location [J]
$\mathbf{F}$ = is the force vector [N]
$\mathbf{d}$ = is the distance vector over which the force is applied[m]
F = is the force scalar [N]
d = is the distance scalar [m]
θ = is the angle between the force and distance vectors
$d\mathbf{s}$ = differential displacement of the charge [m]
V = volts [V]
q = charge [C]

$$W_{a\to b} = \int_a^b \vec{F} \cdot d\vec{l} = \int_a^b F\cos\phi\, dl \quad \text{(work done by a force)}$$

$$K_a + U_a = K_b + U_b$$

Electric potential calculations (Relative to $V = 0$ at ∞):

Charge distribution	Electric potential V
Point charge	$\frac{kQ}{r}$
Charged ring of radius a (along its axis, which is taken to be the X-axis)	$\frac{kQ}{\sqrt{x^2+a^2}}$
Charged disc of radius a (along its axis, which is taken to be the X-axis)	$\frac{\sigma}{2\varepsilon_0}\left[\sqrt{x^2+a^2} - \lvert x\rvert\right]$
Sphere of radius a with uniform charge distribution	$\frac{kQ}{r}$ $\quad r \geq a$ $\frac{kQ}{2a}\left[3 - \frac{r^2}{a^2}\right]$ $\quad r \leq a$