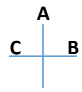
Electricity

- Charges on a plane - C
  - $|a \times b| = ab(\sin\Theta)$
  - $a \bullet b = ab(\cos\Theta)$
- Conductors v. Insulators
  - Conductors = Free electrons
  - Insulators = no free electrons, work required
- Point Charge = Spherical Symmetry
- Electric Field
  - **$E = k|q| / r^2$**
  - **$E = \lambda / 2\pi r^2\varepsilon_0$; $\lambda = q / d$**
    - (for an infinite line of charge)
  - **$E = \sigma / 2\varepsilon_0$; $\lambda = q / A$**
    - (for an infinite charged plate)
- Induction Effect – (+) charge induce dipole on neutral objects
- Dipole
  - E_D (dipole) decreases rapidly
  - **p = dipole moment = qd**
  - $E = 2kp/r^3$ (sum of E on a planar charge system)
- Torque
  - $\tau = p \times E$
  - **$\tau = pE(\sin\Theta)$**
- Energy
  - **$U = -pE(\cos\Theta)$**
  - If a dipole starts at an angle, it will oscillate
- Gauss's Law
  - J = Flux = $j \bullet A$
  - $J = jA(\cos\Theta) = jA$
  - $\phi_E = E \bullet A = EA(\cos\Theta)$ = Electric Flux
    - **$\phi_E = \oint E \bullet dA = EA$** (with surface perpendicular to E)
    - Point charge: **$\phi_E = 4\pi r^2 E$**
    - **$\phi_E = q_{enclosed} / \varepsilon_0$**
  - Answers (1) Charge location, (2) E
- Conductors
  - Conductor negates E inside (due to change separation)
- Electric Potential – Scalar
  - **$\Delta V = \Delta U / q$**
  - Parallel capacitor – each plate gives off **$E = \sigma / \varepsilon_0$**
  - $U = -qEx$ ($\Delta U = Eq(x_2 – x_1)$)
  - From above 2 equations, $V = -Ex + C$
    - **$\Delta V = \int E \bullet dL$; $V = kq / r$**
    - **$\Delta V_{point\ charge} = q / 4\pi r\varepsilon_0$**
    - Apply 3 charges on plane separated by r = d
      - Potential at A: $V(A) = V_1$-(A) + $V_2(B)$
      - **$V(A) = [q_1 + q_2] / 4\pi\varepsilon_0 d\sqrt{2}$**



  - V = constant at any point in a conductor
  - E = 0 at any point in conductor
- Capacitance – F - (| | plate capacitor) – origin on the right (negative) plate
  - Parallel plate capacitor charge = equal and opposite on each side
  - **$C = \varepsilon_0 A / d$** (from $V = \int E \bullet dl$, $E_{||} = \sigma / \varepsilon_0$
  - **$U = q^2 2C$**
- Circuits – Capacitance
  - **$q = q_1 + q_2$ (parallel); $q = q_1 = q_2$ (series)**
  - **$V = V_1 = V_2$ (parallel); $V = V_1 + V_2$ (series)**
  - **$C = C_1 + C_2$ (parallel) $C^{-1} = C_1^{-1} + C_2^{-1}$ (series)**
- Dielectrics
  - **$E = V / d$** ; gets smaller with smaller A, larger d
  - **$C = KC_0 = KA\varepsilon_0 / d$**
- Current - Amp
  - Motion of equivalent positive charges
  - $I = \Delta q / \Delta t$
  - **$I = V / R$**
- Resistance - Ω
  - $R = V / I$
  - Higher T → Higher KE → More resistance
  - Resistance is nonconservative
  - **$P = IV = V^2 / R = I^2R$**
- Circuits – Resistors
  - **$R^{-1} = R_1^{-1} + R_2^{-1}$ (parallel)**
  - **$R = R_1 + R_2$ (series)**
- Equivalent Circuits
- RC Circuit
  - $V = q / C + iR$; i = current from capacitor
  - **$q(t) = CV[1 - e^{-t / RC}]$**
  - **$i(t) = Ve^{-t / RC} / R$**

Magnetism

- No point charge
- **$\phi_M = \oint B \bullet dA$** = 0 (closed surface)
- Magnetic force
  - **$F = qv \times B = qvB(\sin\Theta)$**
  - **$F = IL \times B = ILB(\sin\Theta)$**
- Angular motion
  - Uses $a_c = V^2 / r$; $F = ma$; $F_M = qbB(\sin\Theta)$
  - **$\omega = qB / m$** (moving perpendicular to field)
  - **$T = 2\pi / \omega$**
- Magnetic dipole
  - **$\mu_0 = IA$**

    - **$\tau = \mu \times B$**
- Magnetic Current
    - Current flows induce a magnetic field
        - **$\mu_0 = 4\pi(10^{-7})$**
        - Infinite wire = **$\mu_0 I / 2\pi r = B$**
    - Force between 2 wires
        - **$F = \mu_0 I_1 I_2 L / 2\pi d$**
    - Ampere's Law
        - **$\oint B \bullet dL = \mu_0 I$**
        - Surface can be an open surface
- Solenoid - store a charge
    - Magnetic current concentrated in the center
    - **$B = \mu_0 I (N/L)$; $B = n\mu_0 I$**
- Induction
    - Causes – Change in I → E
    - Faraday's Law
        - **$\oint B \bullet bL = -d/dt \int B \bullet dA$**
        - **$\mathcal{E} = d\phi_B / dt$**
        - **$\mathcal{E} = v_0 LB = IR$**
        - **$I = v_0 LB / R$**
    - Lentz's Law
        - Currents (Inducted) counter a B field currently being transmitted to ensure cooperation of 1st law
    - $\mathcal{E}$ only exist $\Delta\phi_B$
    - **$v_{metal} = RMg / (LB)^2$**
    - **$\mathcal{E} = vLB$**
    - **$I = vLB / R$**
    - **Solenoid = $\mu_0 n^2 Al(d\textit{i} / dt) = \Delta V$**

	Electic	Magnetic
Field	**E**	**B**
Potential	**V**	-----------------
Force	**$F_E = Q(E + U \times B)$**	**$F_M = IL \times B$**
Point	**$E = q / 4\pi\varepsilon_0 r$**	-----------------
Line	**$E = \lambda / 2\pi\varepsilon_0 r$**	**$B = B = \mu_0 I / 2\pi r$**
Plane	**$E = \sigma / 2\varepsilon_0$**	**$B = n\mu_0 I$**
Device	**$C = A\varepsilon_0 / d$**	**L =**
Voltage	**$V = q/C$**	**$V = -LBv$**
Energy	**$U_E = ½ CV^2$**	**$U_M = ½ LI^2$**
Dipole	**$P = qd$ $U = -p \bullet E$** **$T = p \times E$**	**$\mu = IA$ $U = -\mu \bullet B$** **$\tau = \mu \times B$**
Maxwell	**$\oint E \bullet dA = q_{enclosed} / \varepsilon_0$** **$\mathcal{E} = -d\phi_e / dt$**	**$\oint B \bullet dA = 0$** **$\oint B \bullet dl = \mu_0 I$**