CHAPTER 1/2 → $F_e = \frac{kq_1q_2}{r^2}$

$\vec{E} = \frac{F_e}{q_0}$, $\vec{E} = \frac{kQ}{r^2}$

CHAPTER 3 → GAUSS' LAW

☆ $\varepsilon_0 \Phi = q_{enc}$, $\Phi \oint \vec{E} \cdot d\vec{A}$

$\vec{E}$ @ particle → $E = \frac{\sigma}{\varepsilon_0}$

$\vec{E}$ @ ∞ line → $E = \frac{\lambda}{2\pi\varepsilon_0}$

$\vec{E}$ @ ∞ sheet → $E = \frac{\sigma}{2\varepsilon_0}$

Outside sphere → $E = \frac{kq}{r^2}$

Inside sphere → $E = \frac{kq}{R^3} r$

CHAPTER 4 → ELECTRIC POTENTIAL

$V = -\frac{W_\infty}{q_0} = \frac{U}{q_0}$, $U = qV$

$K = -q\Delta V + W_{app}$

$V_f - V_i = -\int E \cdot ds$

$\Delta V = -E\Delta x$

PD due to each particle → $V = \frac{kq}{r}$

$V = qk \int \frac{dq}{r}$, $E = -\frac{\Delta V}{\Delta s}$

$U = W = \frac{kq_1q_2}{r}$ for each PAIR

CHAPTER 5 → CAPACITANCE

$q = CV = \varepsilon_0 \oint E dA$, $\varepsilon = k\varepsilon_0$

Parallel Plate → $C = \frac{\varepsilon_0 A}{d}$ ☆

V in ‖

Cylinder → $C = \frac{2\pi\varepsilon_0 L}{\ln(b/a)}$

q in $\frac{I}{I}$ ☆

Sphere → $C = 4\pi\varepsilon_0 \frac{ab}{b-a}$

Isolated Sphere → $4\pi\varepsilon_0 R$

CHAPTER 6 → $i = \int J \cdot dA$

$J = (ne)V_d$, $V = IR$

$U_C = \frac{1}{2}CV^2$

$\rho = \frac{1}{\sigma} = \frac{E}{J}$, $R = \rho\frac{L}{A}$

$\rho - \rho_0 = \rho\alpha(T - T_0)$

$\rho = \frac{m}{e^2 n\tau}$ | $P = iV = i^2R = \frac{V^2}{R}$

☆ Current density always points in direction of conventional current.

CHAPTER 7/8 → MAGNETISM

$F_B = q\vec{V} \times \vec{B} = i\vec{L} \times \vec{B}$ → $\sin\theta$

$qVB = \frac{mV^2}{R}$ → $r = \frac{mV}{qB}$

$f = \frac{\omega}{2\pi} = \frac{1}{T} = \frac{q}{B2m}$

Biot-Savart Law

↳ $dB = \frac{\mu_0 i}{4\pi} = \frac{i ds \times \hat{r}}{r^2}$

$B_{wire} = \frac{\mu_0 i}{2\pi R}$

$B_{1/2\, wire} = \frac{\mu_0 i}{4\pi R}$

$B_{arc} = \frac{\mu_0 i \varphi}{4\pi R}$ (RADS!)

Parallel $I \Rightarrow F_{BA} = \frac{\mu_0 L i_a i_b}{2\pi d}$

↑ ↑

Same attracts, opp repels

AMPERE'S LAW

$\oint B ds = i_{enc}$

$B = \mu_0 i \frac{N}{L}$ (solenoid)

$B = \frac{\mu_0 i N}{2\pi R}$ (toroid)

N = turns/metre

$\varepsilon = BLV$

$i = \frac{BLV}{R}$ $P = \frac{B^2L^2V^2}{R}$

CHAPTER 9 INDUCTION

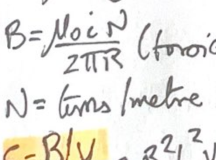
$\Phi_B = \int B dA = BA = NBA$

$U = \frac{Li^2}{2}$ → $u_B = \frac{B^2}{2\mu_0}$

$\varepsilon = \oint E ds$

$\varepsilon = -N\frac{d\Phi_B}{dt}$

$L = N\frac{\Phi_B}{i}$ → $L = \mu_0 n^2 A l$ (solenoid)



$V = L\frac{di}{dt}$

$B = \frac{\mu_0 i N}{L}$ (solenoid)

$\Phi_B = NBA$ (coil)

$\varepsilon = -N\frac{d\Phi_B}{dt}$

☆ HALL EFFECT → PD due to current in wire w/ $\vec{B}$

☆ EARNSHAW → No system of free particles can reach equilibrium

☆ FARADAY'S LAW → Change in ε in loop induces current in loop

☆ LENZ'S LAW → Induced current will produce B to oppose change in external B.

☆ TELLEGEN's THEOREM → $\Sigma P = 0$ for any network

CIRCUITS → MISCELLANEOUS

KCL → $\Sigma I = 0$ for a node

KVL → $\Sigma V = 0$ for a closed loop

Max Power → when $R_L = R_{th} = \frac{V^2}{4R_{Th}}$

Current division → $I_1 = \frac{R_2}{R_1 + R_2} I_0$

Voltage division → $V_1 = \frac{R_1}{R_1 + R_2} V_0$

Nodal Analysis → N−1 equations

Loop Analysis → B−N+1 equations

TECHNIQUES
1. NODAL
2. LOOP
3. SUPERPOSITION
4. THEVENIN
5. NORTON
6. SOURCE TRANSFORMATION

TRANSIENT CIRCUITS

	CHARGED	DISCHARGED
CAPACITOR	Voltage Source (OPEN)	Open circuit
INDUCTOR	Current Source (SHORT)	Open circuit

$U = \frac{1}{2}CV^2 = \frac{1}{2}Li^2$

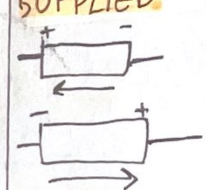
Capacitor → $\tau = R_{th}C$

Inductor → $\tau = L/R_{th}$

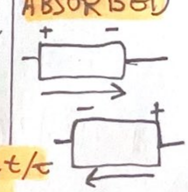
$V = L\frac{di}{dt}$, $i = C\frac{dv}{dt}$

$V_C = \frac{di_C}{dt}$ $i_C = \frac{dv_C}{dt}$

SUPPLIED

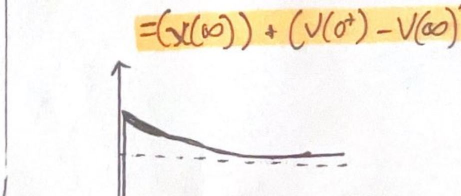


ABSORBED



☆ $x(t) = K_1 + K_2 e^{-t/\tau}$

$= (x(\infty)) + (V(0^+) - V(\infty)) e^{-t/\tau}$



CONSTANTS

Electric Constant $\rightarrow k = \frac{1}{4\pi\varepsilon_0} = 8.99\times10^{9}\ \frac{Nm^2}{C^2}$

Permittivity of Free Space $\rightarrow \varepsilon_0 = 8.85\times10^{-12}\ \frac{C^2}{Nm^2}$

Elementary Charge $\rightarrow 1.602\times10^{-19}\ C$

Electron Mass $\rightarrow 9.11\times10^{-31}\ kg$

Proton/Neutron mass $\rightarrow 1.67\times10^{-27}\ kg$

Permeability $\rightarrow \mu_0 = 4\pi\times10^{-7}\ \frac{N}{A^2}$
$= 12.566\times10^{-7}$

UNITS

Current $\rightarrow A = \frac{C}{s}$

Electric Field $\rightarrow \frac{N}{C} = \frac{V}{m}$

Electric Flux $\rightarrow Vm$

Capacitance $\rightarrow F = C/V$

Resistance $\rightarrow \Omega = \frac{V}{A}$

Resistivity $\rightarrow \Omega m$

Power $\rightarrow W = \frac{J}{s}$

Mag Field $\rightarrow T = \frac{N}{A\cdot m}$

Mag Flux $\Rightarrow Wb = T\cdot m^2$

Inductance $\rightarrow H = \frac{Tm^2}{A}$

Sine Law $\rightarrow \frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$

Cosine Law $\rightarrow C^2 = A^2 + B^2 - 2AB\cos\Theta$

Sphere $\rightarrow V = \frac{4}{3}\pi R^3,\ SA = 4\pi R^2$

Cylinder $\rightarrow V = \pi R^2 h,\ SA = 2\pi r(r+h)$

	PARALLEL	SERIES
C	ΣC_j	$\Sigma \frac{1}{C_j}$
R	$\Sigma \frac{1}{R_j}$	ΣR_j
L	$\Sigma \frac{1}{L_j}$	ΣL_j
$\mathbb{Z}$	$\Sigma \frac{1}{Z_j}$	ΣZ_j

AC CIRCUITS

$\mathbb{Z} = \underbrace{R(\omega)}_{\text{resistance}} + j\underbrace{X(\omega)}_{\text{reactance}}$

Inverse of resistance $\rightarrow$ conductance
Inverse of reactance $\rightarrow$ susceptance
Inverse of impedance $\rightarrow$ admittance

 $\rightarrow +1\ \Omega \rightarrow \mathbb{Z} = R$

 $\rightarrow -j\ \Omega \rightarrow \mathbb{Z} = j\omega L = jX_L$

 $\rightarrow j\ \Omega \rightarrow \mathbb{Z} = \frac{1}{j\omega C} = -j\omega C = jX_C$

 $\rightarrow v(t) = R\,i(t)$

 $\rightarrow v(t) = \frac{1}{C}\int_{-\infty}^{t} i(x)\,dx$

 $\rightarrow i(t) = \frac{1}{L}\int_{-\infty}^{t} v(x)\,dx$

PHASOR RELATIONSHIPS

Resistors $\rightarrow \Theta_v = \Theta_i \rightarrow$ always in phase

Capacitors $\rightarrow \Theta_v = \Theta_i + 90° \rightarrow$ voltage leads by 90°

Inductors $\rightarrow \Theta_i = \Theta_v + 90° \rightarrow$ current leads by 90°

PHASOR NOTATION & ARITHMETIC

$A\cos(\omega t + \Theta) = A\angle\Theta$ $\rightarrow$ Phase angles based off cosine

$\cos\Theta = \sin(\Theta + 90)$ AND $\sin\Theta = \cos(\Theta - 90)$

★ Angular Frequency is common factor, do not consider in solving.

$\omega = 2\pi f$

ADMITTANCE $\rightarrow \mathbb{Y} = \frac{1}{\mathbb{Z}}$

$R \rightarrow \mathbb{Y}_R = 1/G = G$

$L \rightarrow \mathbb{Y}_L = 1/j\omega L = -1/\omega L \angle 90°$

$C \rightarrow \mathbb{Y}_C = j\omega C = \omega C \angle 90°$

CRAMER'S RULE

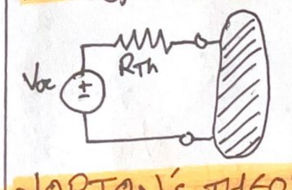
$$\begin{bmatrix} j2^{Ⓐ} & 4+j3^{Ⓑ} \\ 10-j6^{Ⓒ} & j2^{Ⓓ} \end{bmatrix}\begin{bmatrix} \mathbb{I}_1 \\ \mathbb{I}_2 \end{bmatrix} = \begin{bmatrix} 10\angle 0°^{Ⓔ} \\ 0^{Ⓕ} \end{bmatrix}$$

$$\mathbb{I}_1 = \frac{\Delta_1}{\Delta} = \frac{\begin{vmatrix} E & B \\ F & D \end{vmatrix}}{\begin{vmatrix} A & B \\ C & D \end{vmatrix}} = \frac{ED - BF}{AD - BC}$$

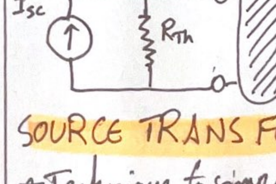
$$\mathbb{I}_2 = \frac{\Delta_2}{\Delta} = \frac{\begin{vmatrix} A & E \\ C & F \end{vmatrix}}{\begin{vmatrix} A & B \\ C & D \end{vmatrix}} = \frac{AF - EC}{AD - BC}$$

★If asked for Thevénin equivalent at terminals, INCLUDE. If asked for Thevénin voltage across (load) resistor, don't include.

THEVÉNIN'S THEOREM



NORTON'S THEOREM



SOURCE TRANSFORMATION

★Technique to simplify Thevénin and Norton Theorems

★THREE TYPES OF THEVENINS

① Indp ONLY $\rightarrow$ Zero all sources
② Dep ONLY $\rightarrow$ Inject voltage
③ BOTH $\rightarrow$ Find V_{oc} & I_{sc} $R_{Th} = \frac{V_{oc}}{I_{sc}}$