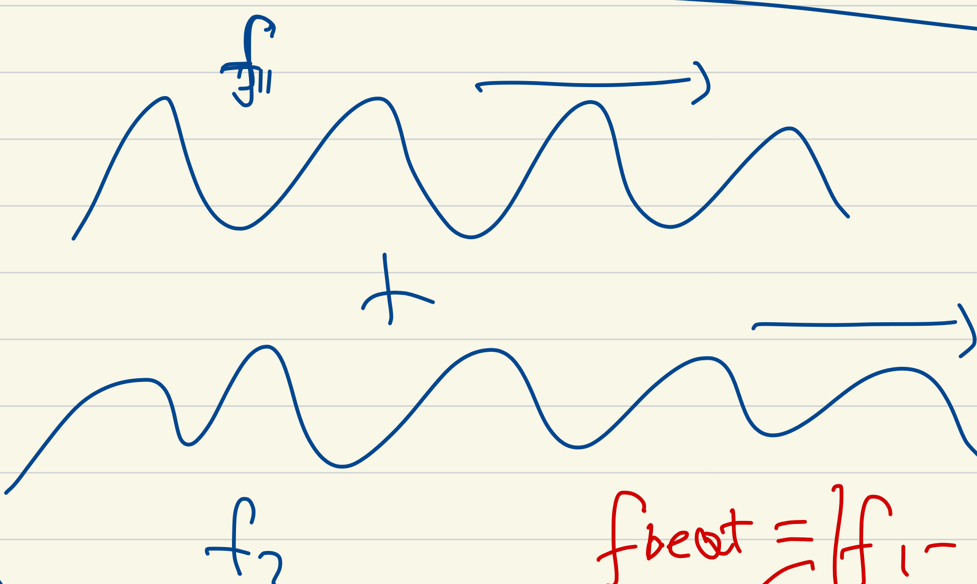
1B Review Session

- doppler, beats
- capacitance.
- resistance / ohms.
- circuits.

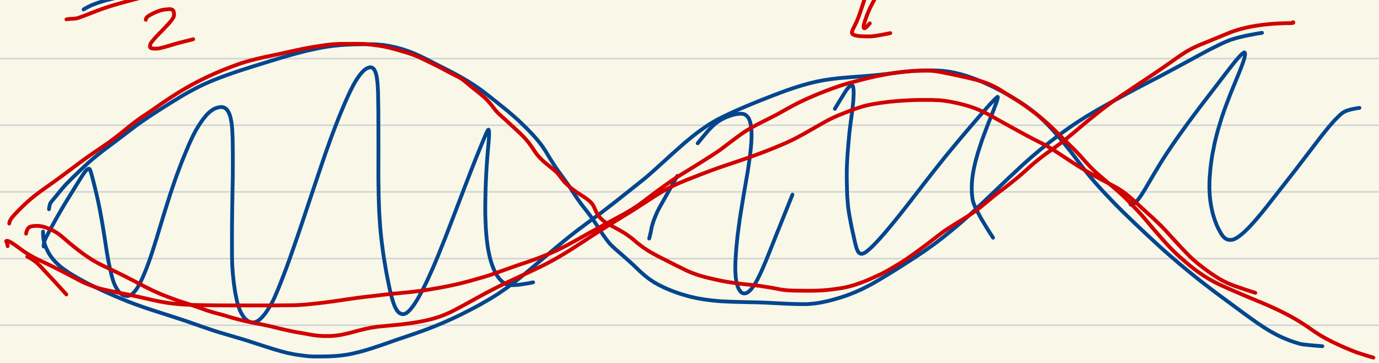
Beats:

$f_1 \sim f_2$

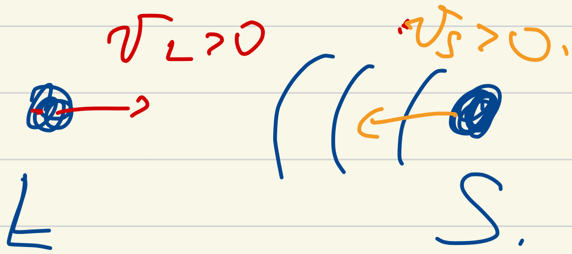


$f_{av} = \frac{f_1+f_2}{2}$

$f_{beat} = |f_1 - f_2|$



Doppler Effect:



$$f_L = \left(\frac{v + v_L}{v - v_S}\right) f_S.$$

f_L f_S

$$f_L = \left(\frac{1 + v_L/v}{1 - v_S/v}\right) f_S$$

v = Speed of sound in air

$1 + v_L/v > 1$.

$1 - v_S/v < 1$.

---

ex: Bat

emitted by bat → $f = 1.7\ kHz$

v_B.

f_L

L. $v_L = 0$.

$$f_L = \frac{v}{v - v_B} \cdot f.$$

$$\frac{1}{1 - v_B/v}$$

heard by bat → f'

f_L.

$$f_{beat} = |f' - f| = 8\ Hz.$$

Bat V_B = (Listener)'

$f_L = f_S$ wall source

$$f' = \left(\frac{V + V_B}{V}\right) \cdot f_L = \left[\left(V + V_B\right)/\left(V - V_B\right)\right] f$$

3.

$$f' = \frac{\overbrace{v+v_B}^{}}{v - v_B} \underbrace{f}_{1.7\,kHz} > f.$$

$$f' \;\;\text{"}\;\; f + 8\,Hz$$

$$\underbrace{\frac{1+v_B/v}{\underbrace{1-v_B/v}_{\substack{v \\ 2.}}}}$$

$$0 < v_B < v$$

Taylor expand

$\underline{v_B \ll v}$

$$\approx \left(1+v_B/v\right)\left(1+v_B/v\right)$$

$$\approx 1 + \frac{2v_B}{v} + \cdots$$

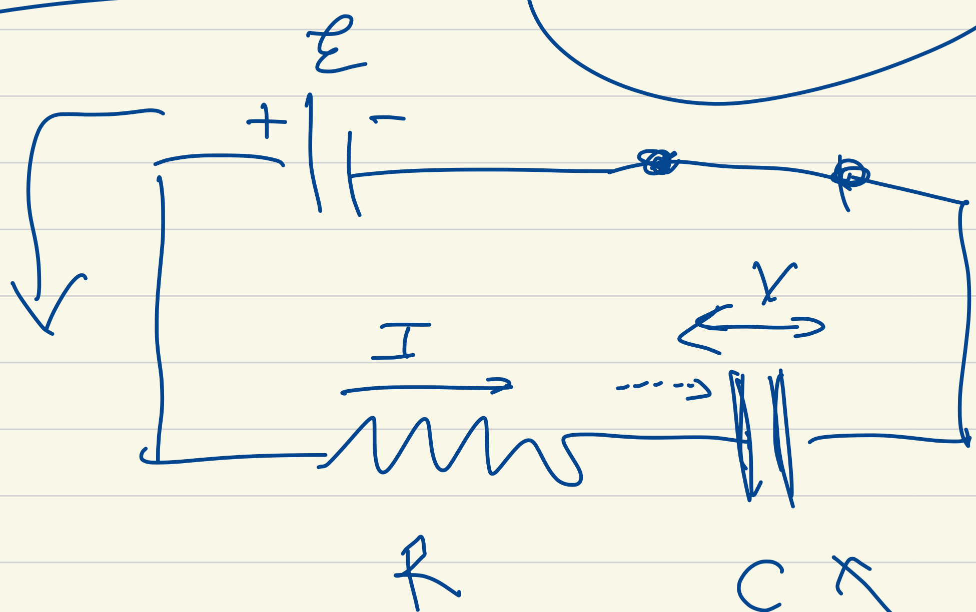
$$\underbrace{f'}_{} = f + 8\,Hz$$

$$\left(1+\frac{2v_B}{v}\right)\cdot f \Rightarrow \frac{\cancel{2}v_B}{v} = \frac{8\,Hz}{f} = \frac{\cancel{8}^{\,4}}{1700}$$

$$v_B = \underbrace{v}_{340\frac{m}{s}} \cdot \underbrace{\frac{4}{1700}}_{\approx \frac{1}{400}} \sim 0.8\ \frac{m}{s}.$$

Capacitance:

$$Q = CV$$



$Q(0) = 0$.

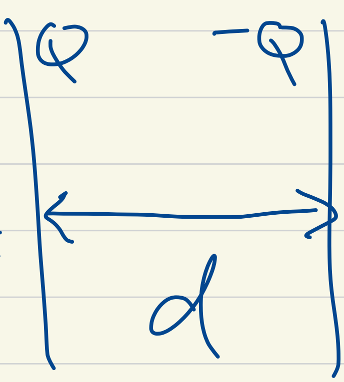
$t = 0$

$-IR$.

$t \gg RC$, $V = \mathcal{E}$, $Q = C \cdot \mathcal{E}$.

$I = 0$

$u \sim 1/d \, V^2$

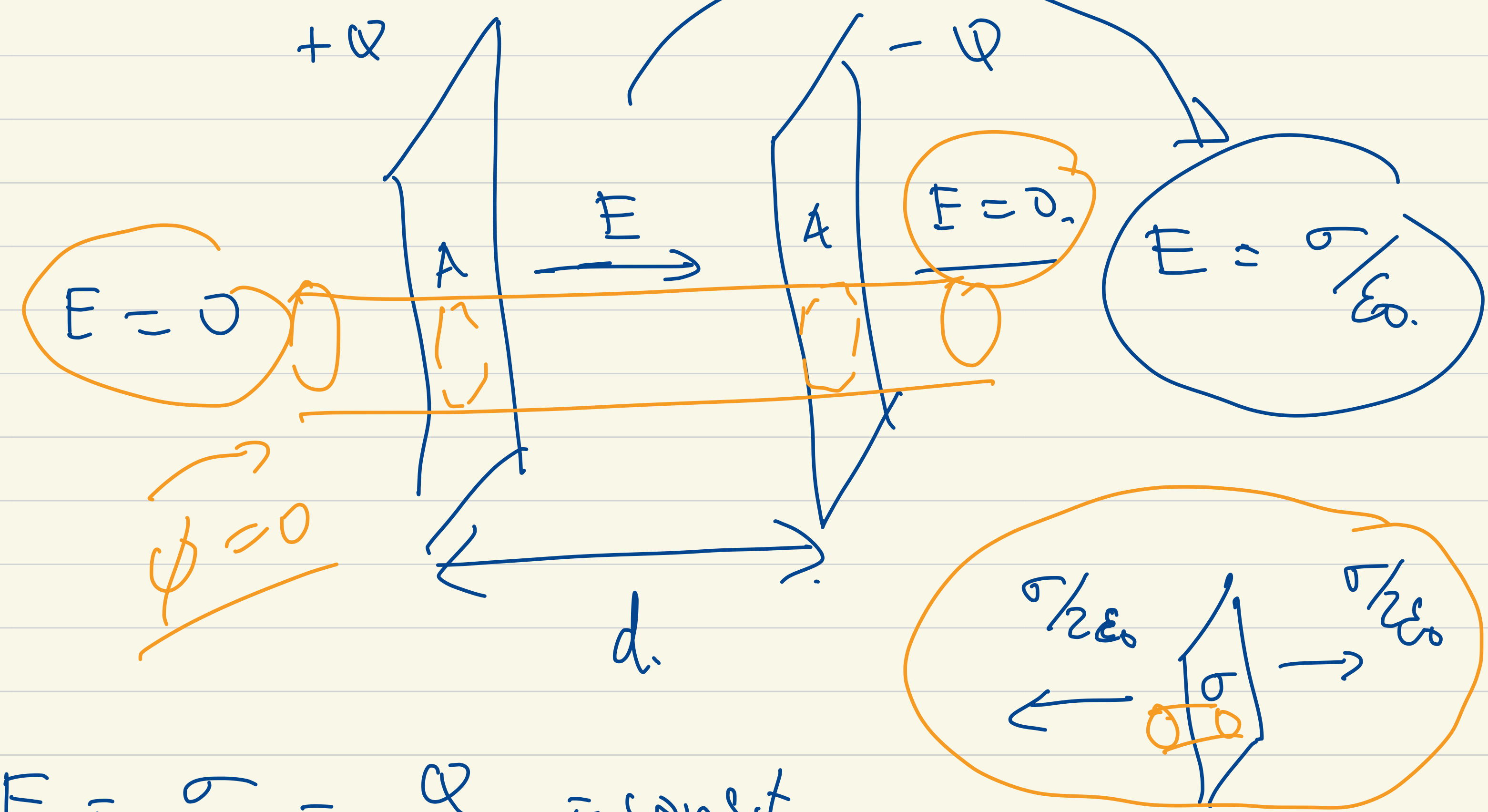


$$C = \epsilon_0 \frac{A}{d}$$

$$U = \frac{1}{2} C \cdot V^2 = \frac{Q^2}{2C}$$

$C \sim 1/d$.

$u \sim d \cdot Q^2$



$$E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{\varepsilon_0 \cdot A} = \text{const.}$$

$$\sigma = \frac{Q}{A}$$

$$V = \underline{E \cdot d} = \frac{Qd}{\varepsilon_0 \cdot A}.$$

$$V \leftarrow \int \vec{E}' \cdot d\vec{x}'$$

$$C = Q/V = \frac{\cancel{Q}}{\cancel{Q}d/\varepsilon_0 A} = \varepsilon_0 \frac{A}{d}$$

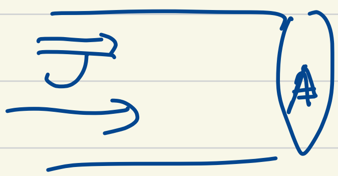
ohm

$$\vec{J} = \sigma \vec{E}$$

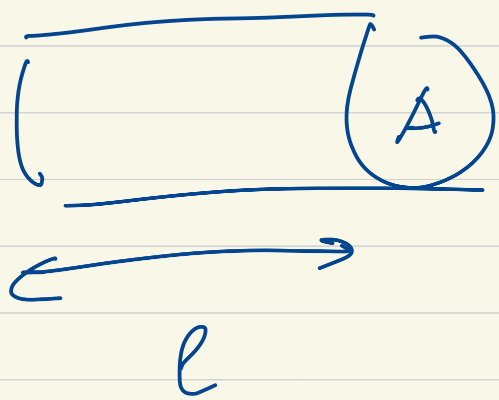
conductivity

$$\sigma = \frac{1}{\rho}$$

resistivity.



$$I = J \cdot A.$$



$$R = \rho \cdot \frac{l}{A}$$

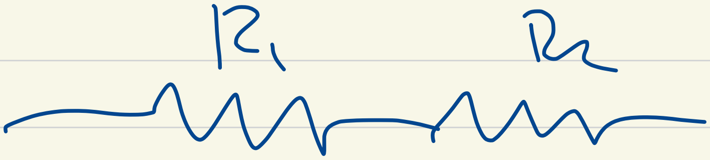
ohm:

$$V = IR$$

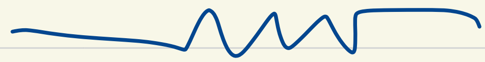
$$I = \frac{V}{R}$$

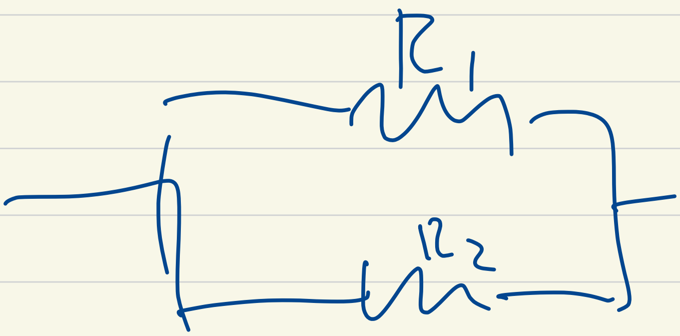
$$J = \underbrace{\frac{1}{\rho}}_{\sigma} \underbrace{\left(\frac{V}{l}\right)}_{E}$$

$$\underbrace{\frac{I}{A}}_{J} = \frac{V}{\underbrace{A \cdot R}_{\rho l}}$$



$$R_{eq} = R_1 + R_2$$

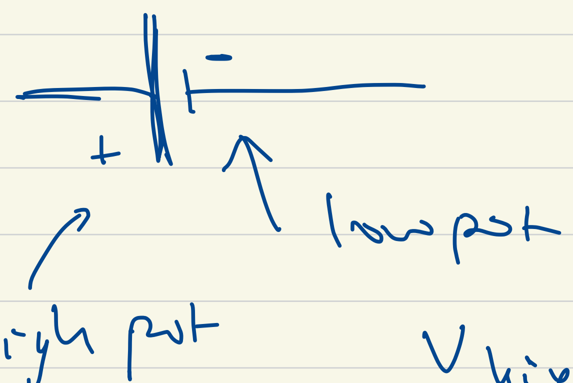




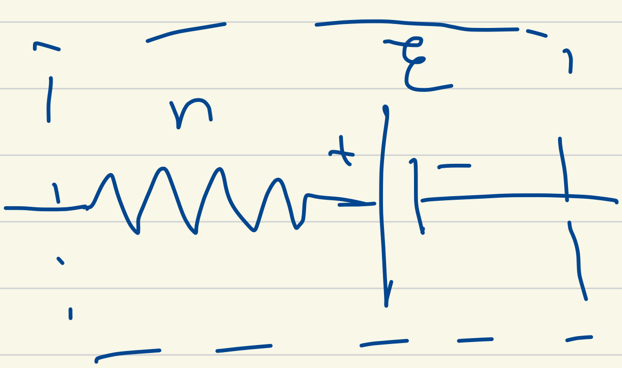
$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

Batteries:



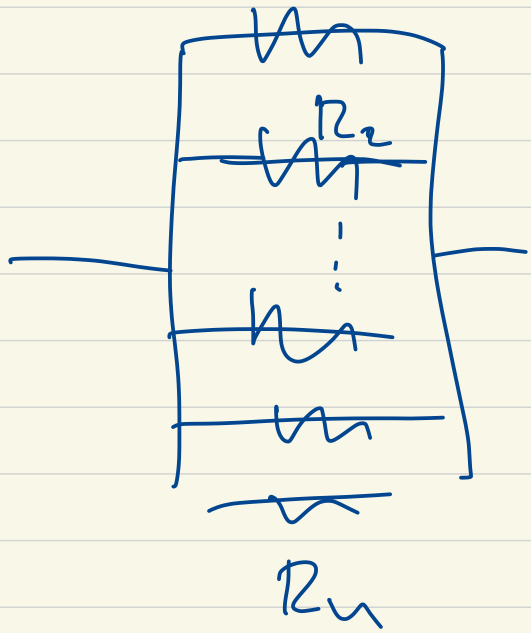
$$V_{high} - V_{low} = \underbrace{e.m.f}_{\mathcal{E}}$$



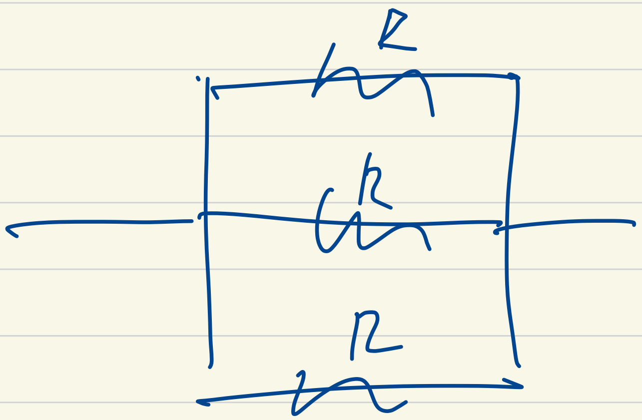
"ideal battery"

real battery w/ internal resistance.

8

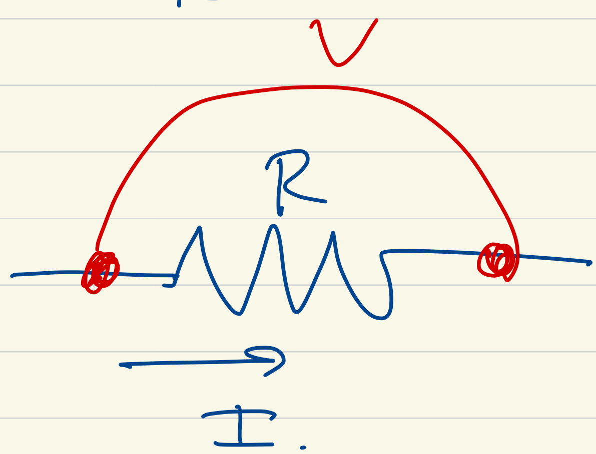


$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \cdots + \frac{1}{R_n}$$



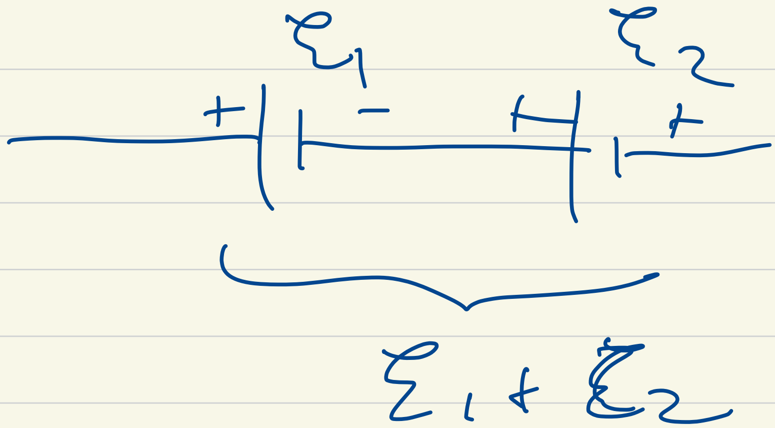
$$\Rightarrow \frac{1}{R_{eq}} = \frac{3}{R} \Rightarrow R_{eq} = \frac{R}{3}$$

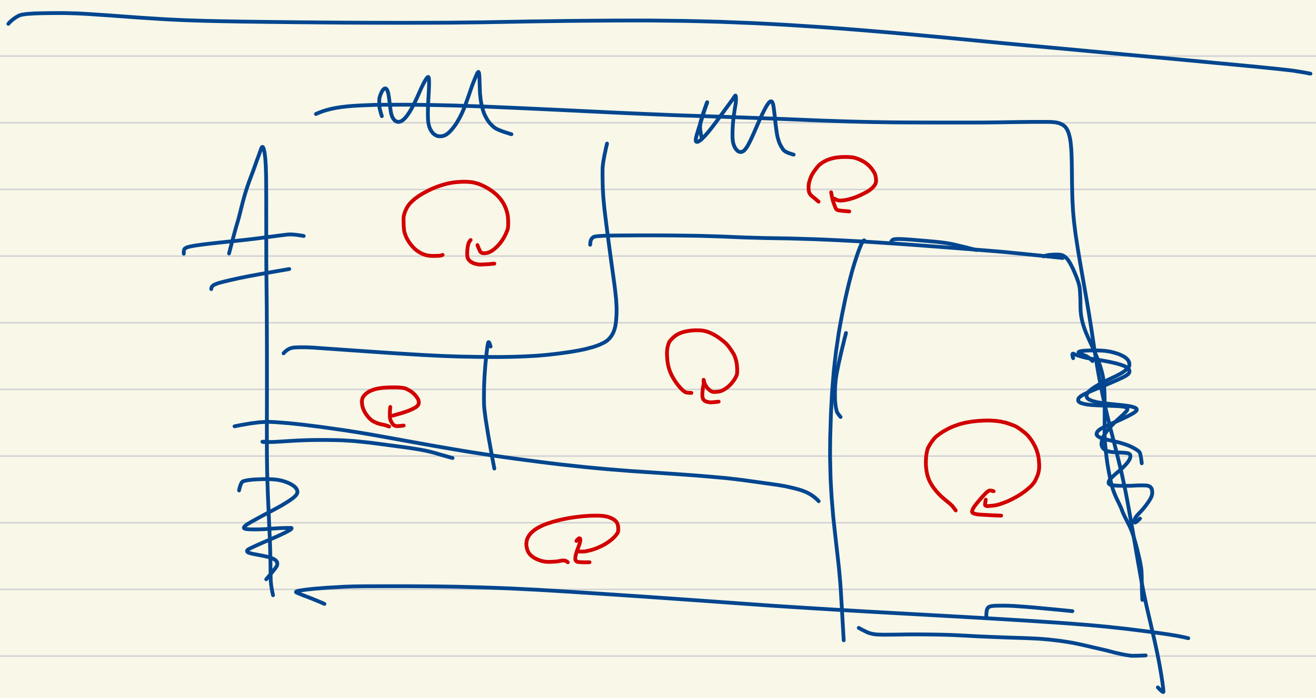
Power dissipated

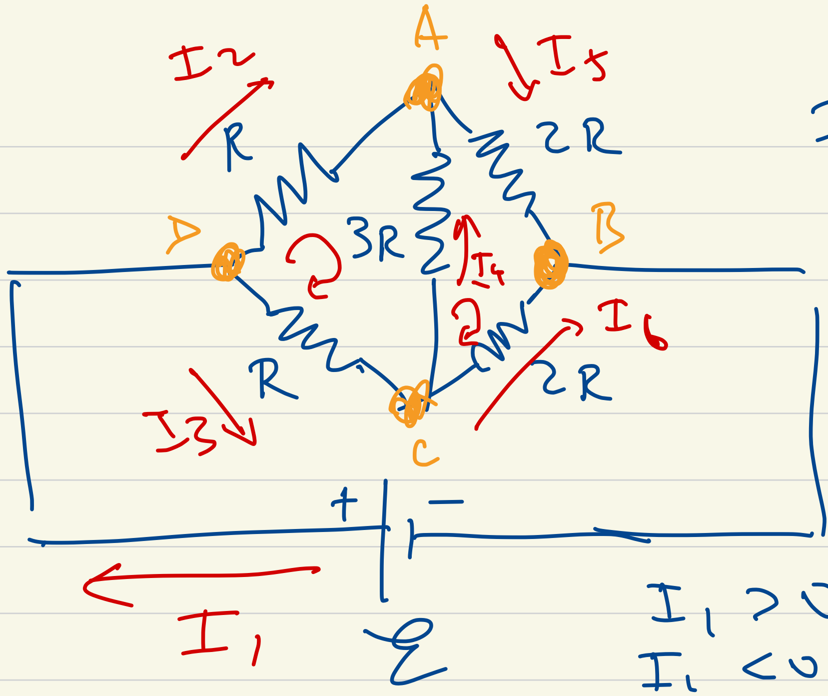


$$P_{dissipated} = I \cdot \underbrace{V}_{I \cdot R}$$

$$= I^2 R = V^2/R.$$


ε1
ε2
+
−
ε1 + ε2





$I_2 = I_3$

$I_5 = I_6$.

$I_4 = 0$

$I_1 > 0$ current $\leftarrow$

$I_1 < 0$ current $\rightarrow$

What is the current in resistor 3R?

A: zero Prove it!

(A) $$\sum_{\text{incoming}} I_i = \sum_{\text{outgoing}} I_j$$

$$\sum_{\text{inc.}} I_i - \sum_{\text{out}} I_j = 0.$$

in: I_2, I_4 out I_5

(A) $\boxed{I_2 + I_4 = I_5}$

(B) $\boxed{I_5 + I_6 = I_1}$

(C) $I_3 = I_4 + I_6$

(D) $I_1 = I_2 + I_3$

$I_1, I_2, I_3, I_4, I_5, I_6 \rightarrow$ 6 unk.

(A) $\boxed{I_2 + I_4 = I_5}$

(B) $\boxed{I_5 + I_6 = I_1}$

(C) $I_3 = I_4 + I_6$

(D) $I_1 = I_2 + I_3$

known

unknown.

$I_5 = I_2 + I_4$

$I_3 = I_4 + I_6$

known

$I_1 = I_2 + I_3$

$= I_2 + I_4 + I_6$

(B) $\underbrace{I_5}_{I_2+I_4} + I_6 = \underbrace{I_1}_{I_2+I_4+I_6} \Longrightarrow 0 = 0$

Redundant

I_2, I_4, I_6 still unknown

$-\cancel{R} I_2 + 3\cancel{R} I_4 + I_3 \cancel{R} = 0$

$$\boxed{-I_2 + 4 \cdot I_4 + I_6 = 0}$$

$$-3\cancel{R}\cdot I_4 - 2\cancel{R}\, I_5 + 2\cancel{R}\cdot I_6 = 0$$

$$I_5 = I_2 + I_4$$

$$-3I_4 - 2\cdot I_4 - 2\cdot I_2 + 2\cdot I_6 = 0$$

$$\boxed{-5\cdot I_4 - 2\cdot I_2 + 2I_6 = 0}$$

$$+\frac{\varepsilon}{R} - I_3\cancel{R} - 2\cancel{R}\, I_6 = 0$$

$$I_3 = I_4 + I_6$$

$$\varepsilon/R = I_4 + \underbrace{I_6 + 2I_6}_{3I_6.}$$

$$\boxed{3I_6 + I_4 = \varepsilon/R}$$

$$I_2 = 4 \cdot I_4 + I_6$$

$$-5 \cdot I_4 - 2 \cdot I_2 + 2 I_6 = 0$$

$$\Rightarrow -5 I_4 - 8 I_4 - \cancel{2 I_6} + \cancel{2 I_6} = 0$$

$$-13 \cdot I_4 = 0$$

$$\Rightarrow I_4 = 0$$

$$\Rightarrow \boxed{\begin{array}{l} I_2 = I_6 = \dfrac{\varepsilon}{3R} \\ \shortparallel \\ I_3 = I_5 \end{array}}$$