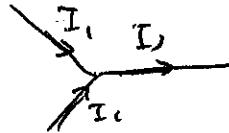


LECTURE 4/25/23

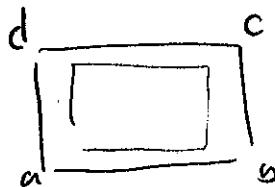
KIRCHHOFF'S RULES

KIRCHHOFF'S RULE.

1. CONSERVATION OF CHARGE

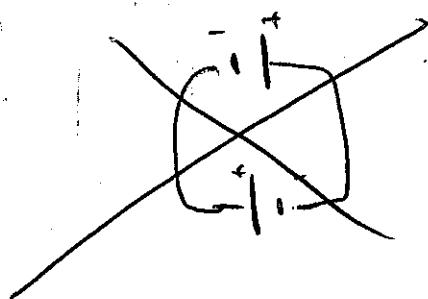


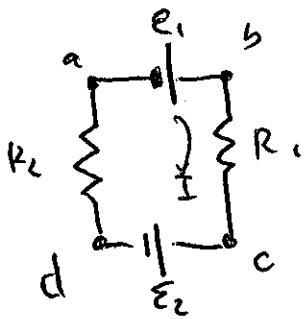
2. CONSERVATION OF ENERGY



$$\sum_{\text{CLOSED LOOP}} \Delta V = 0$$

2. EASY EXAMPLE





$$\sum \Delta V = 0$$

$$a \rightarrow b + E_1$$

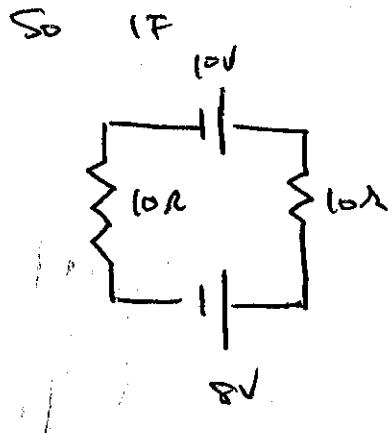
$$E_1 - IR_1 - E_2 - IR_2 = 0$$

$$b \rightarrow c - IR_1$$

$$c \rightarrow d - E_2$$

$$d \rightarrow a - IR_2$$

~~(F) EXERCISE~~
~~ANSWER~~



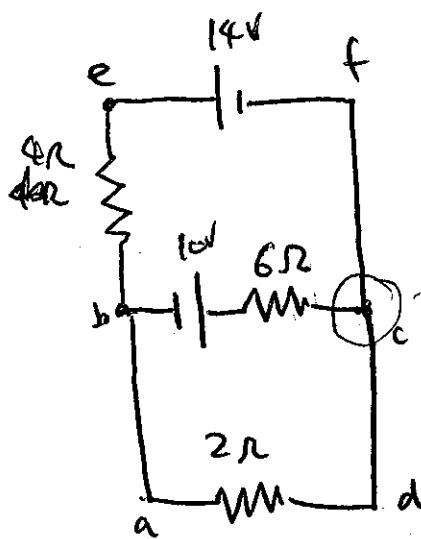
$$10V - I10\Omega - 8V - I10\Omega = 0$$

$$2V = Iz_0\Omega$$

$$\boxed{\frac{1}{10}A = I}$$

EXAMPLE 2

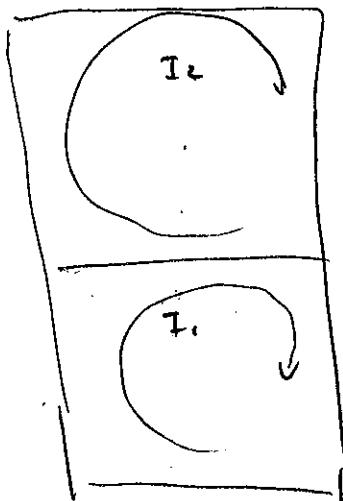
P3



FIND CURRENTS

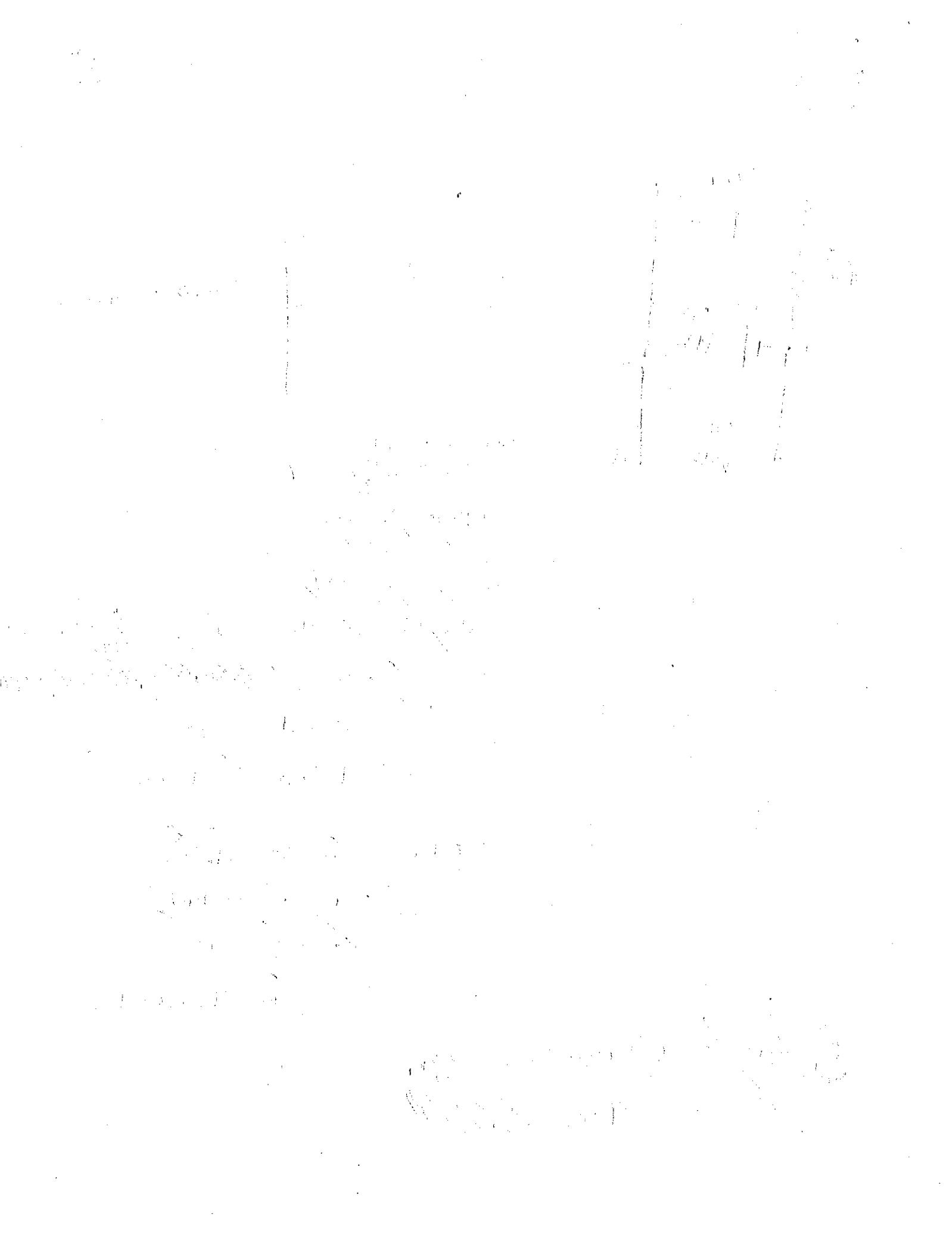
WALK THROUGH
THIS ONE slowly

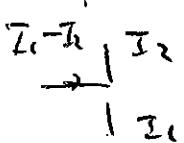
CLOSED LOOPS



$$\begin{aligned}
 \text{abcd: } & \quad a \rightarrow b \quad \Delta V = 10V - 6I_1 + 6I_2 \\
 & \quad b \rightarrow c \quad \Delta V = 10V - 6I_1 + 6I_2 \\
 & \quad c \rightarrow d \quad \Delta V = 0 \\
 & \quad d \rightarrow a \quad -I_1, 2\Omega \\
 \text{befc: } & \quad b \rightarrow e \quad \Delta V = 4\Omega I_2 - 4\Omega I_1 \\
 & \quad e \rightarrow f \quad -14V \\
 & \quad f \rightarrow c \quad 0 \\
 & \quad c \rightarrow b \quad -I_2, 6\Omega - 10V
 \end{aligned}$$

$$\begin{aligned}
 \text{abcd: } & \quad 0 = 0 + 10V - 6I_1 + 6I_2 \\
 & \quad 10V - 6I_1 + 6I_2 = 0
 \end{aligned}$$





$$10V - 10V - 6(I_1 - I_2) - 2I_1 = 0$$

$$10V - 6I_1 + 6I_2 - 2I_1 = 0$$

$$8I_1 - 6I_2 = 10V$$

~~$$(-8 + 18)$$~~

2nd ^{loop}

$$4I_2 - 14 - 6(I_2 - I_1) - 10V = 0$$

$$-10I_2 + 6I_1 = 24$$

~~$$\left\{ \begin{array}{l} 8I_1 - 6I_2 = 10V \\ -10I_2 + 6I_1 = 24 \end{array} \right.$$~~

~~$$\times \frac{4}{3}$$~~

$$8I_1 - 6I_2 = 10V$$

$$-\frac{40}{3}I_2 + 8I_1 = 32$$

~~$$-$$~~

$$\left(-6 + \frac{40}{3} \right) I_2 = -22V$$

$$\frac{22}{3} I_2 = -22V$$

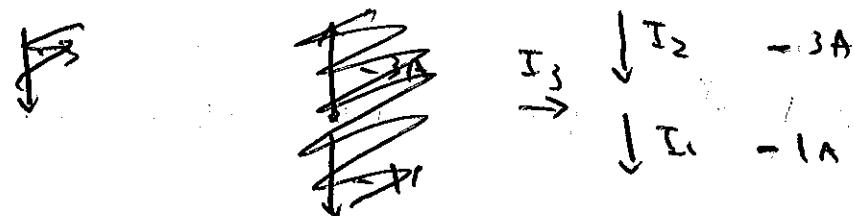
$$I_2 = -3A$$

~~ANSWER~~

POT INTO 2)

$$+30V - 6I_1 = 24$$

$$I_{11} = -1A$$

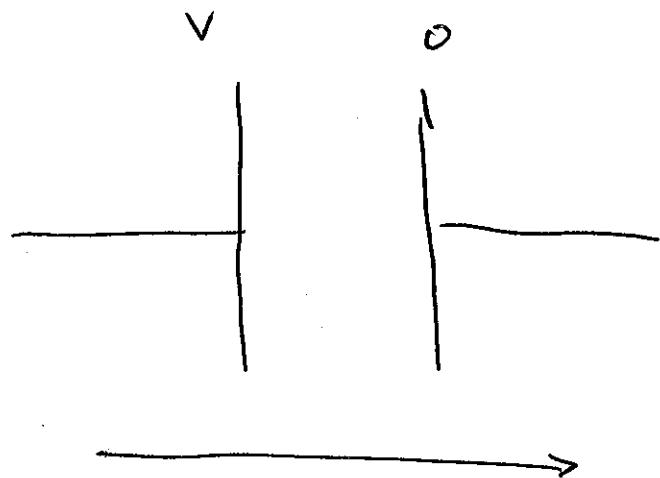


$$I_2 + I_3 = I_1$$

$$-3A + I_3 = -1A$$

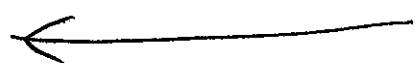
$$\underline{I_3 = 2A}$$

CAPACITORS How??



A graph showing a linear relationship between charge Q and voltage V . The graph starts at the origin and slopes upwards to the right. To the right of the graph, the equation $\Delta V = \frac{Q}{C}$ is written, with two parallel lines under the fraction.

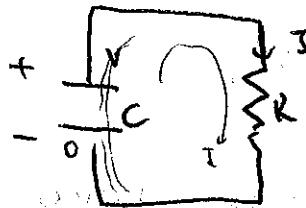
$$\Delta V = \frac{Q}{C}$$



$$\Delta V = -\frac{Q}{C}$$

RC CIRCUITS

CAPACITOR



$$V(t)$$

$$Q(t)$$

$$\frac{dQ}{dt} = I(t)$$

$$I = \frac{V(t)}{R}$$

$$Q = CV$$

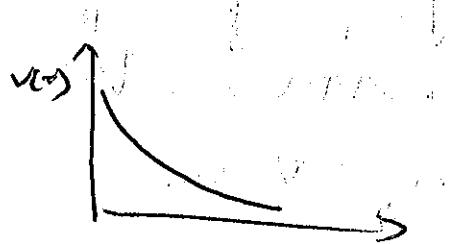
$$C \frac{dV}{dt} = -\frac{V(t)}{R}$$

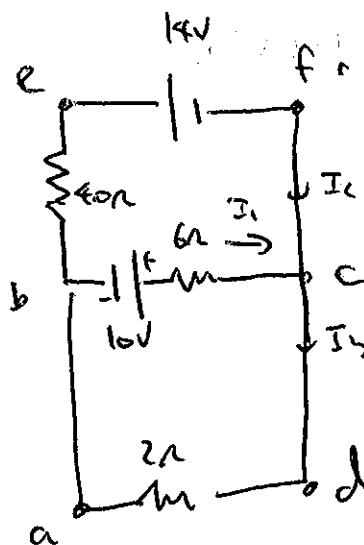
$$\frac{dV}{dt} = -\frac{V}{RC}$$

$$\frac{dV}{V} = \frac{dt}{RC}$$

$$\int \frac{dV}{V} = -\frac{t}{RC}$$

$$V(t) = e^{-\frac{t}{RC}}$$



EXAMPLEFIND I_1, I_2, I_3 ,

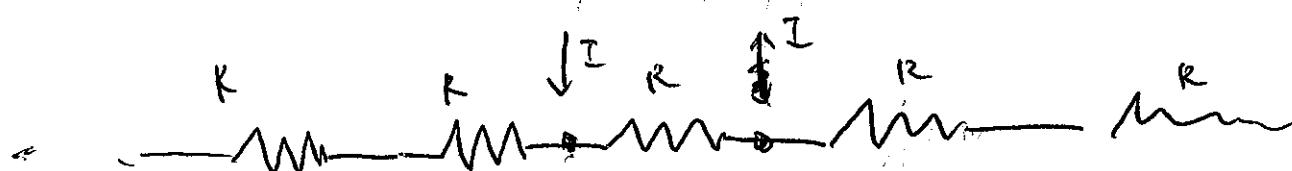
$$I_1 + I_2 - I_3 = 0 \quad \text{KIRCHOFF'S LAW.}$$

FOR SET UP SEE P5

$$abcda = 0 + 10V - I_1 6\Omega - I_3 2\Omega = 0$$

$$befcb = -I_2 4 - 14V + 6I_2 I_1 - 10V = 0$$

SUPERPOSITION LINES

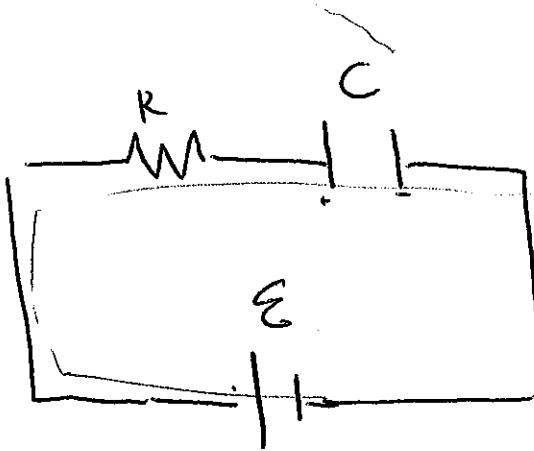


$$\frac{I_1}{R} \rightarrow \frac{I_2}{R} \leftarrow \frac{I}{R} \quad V = \underline{\underline{IR}}$$

$$\frac{I_1}{R} \rightarrow \frac{I_2}{R} \leftarrow \frac{I}{R}$$

$$\cancel{\frac{I_1}{R} \rightarrow \frac{I_2}{R}}$$

$$\overrightarrow{I}$$



KIRCHHOFF'S LAW

$$\mathcal{E} - \cancel{IR} - \frac{q}{C} = 0$$

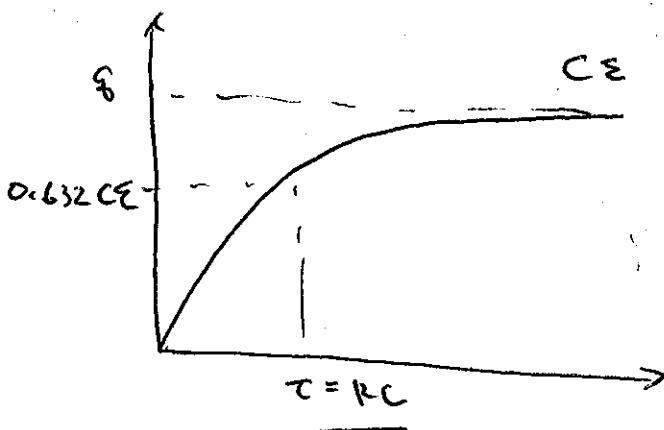
$$\mathcal{E} - \frac{dq}{dt}R - \frac{q}{C} = 0$$

$$\frac{dq}{dt} = \frac{\mathcal{E}}{R} - \frac{q}{RC}$$

$$= \frac{\mathcal{E}C - q}{RC}$$

$$q(t) = C\mathcal{E}(1 - e^{-\frac{t}{RC}})$$

$$\tau = RC$$



$e^{-t/\tau}$

$0.368 \approx e^{-1}$

MONDAY EM 367 OHM'S LAW

WED EM 373 LIGHT BULBS, EM 361 HAND BATTERY

FRIDAY EM 382 DISCHARGING THRU A VOLTmeter