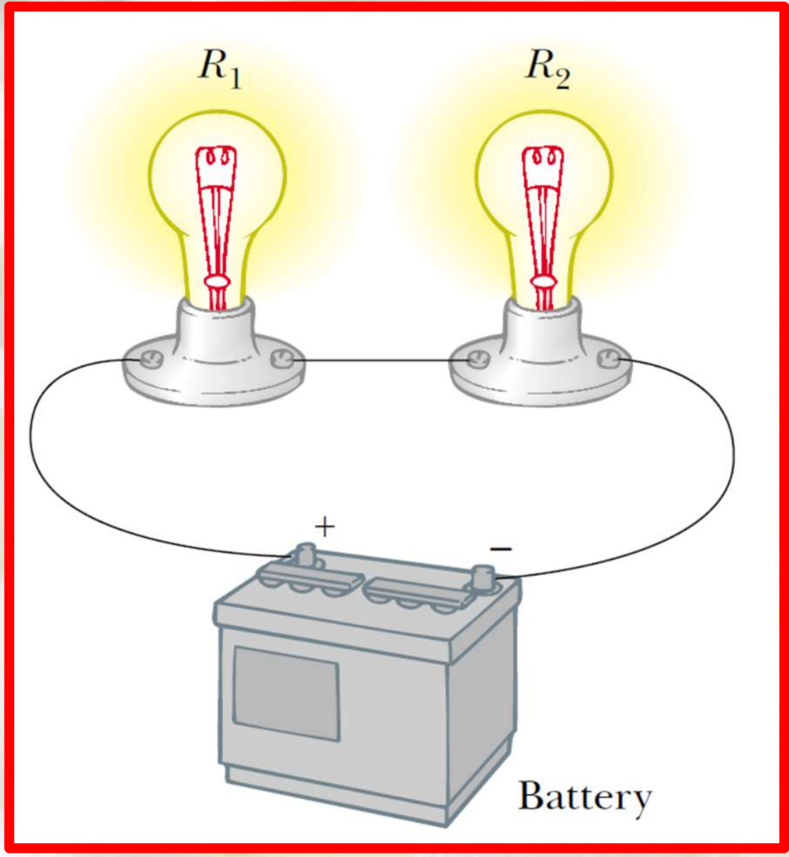
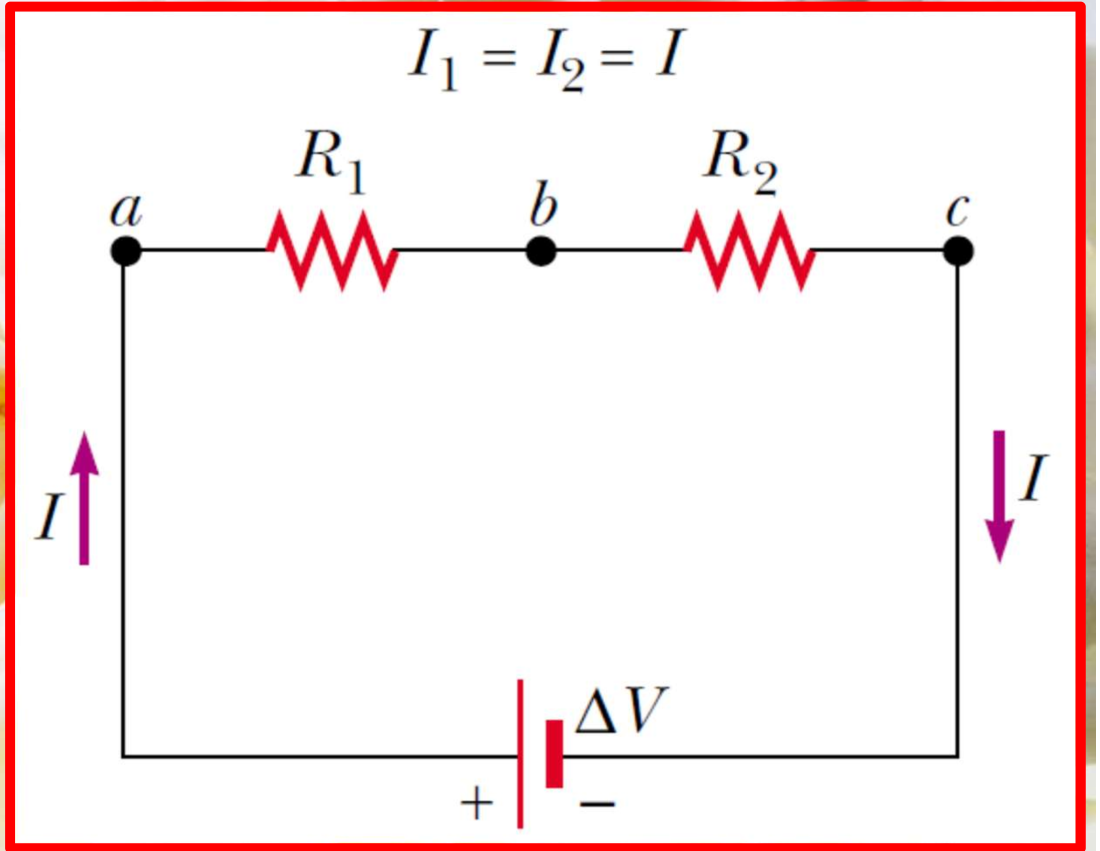
به هم بستن سری مقاومتها





$$V = R_{eq} I$$

$$V_1 = R_1 I$$

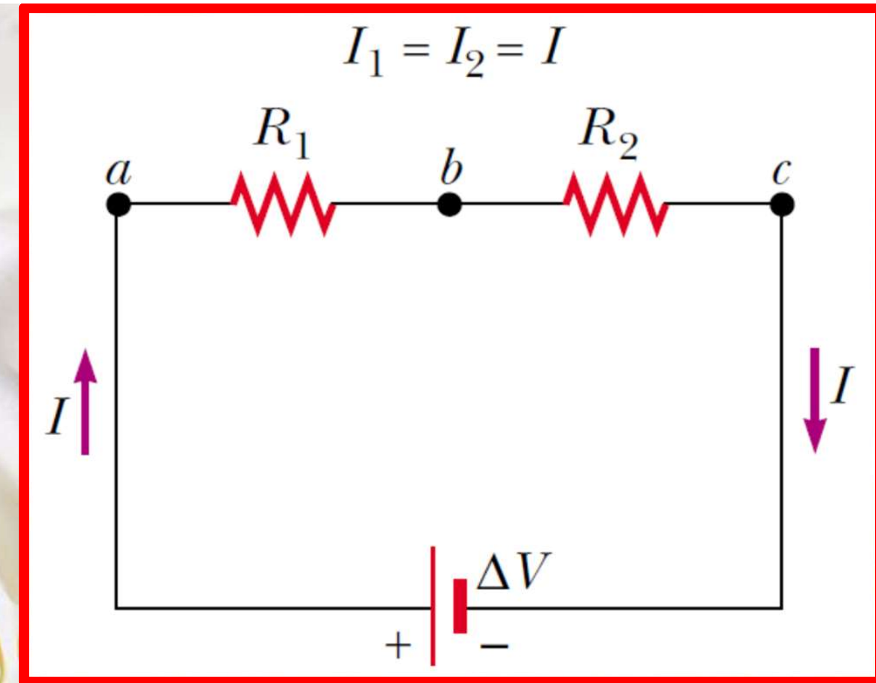
$$V_2 = R_2 I$$

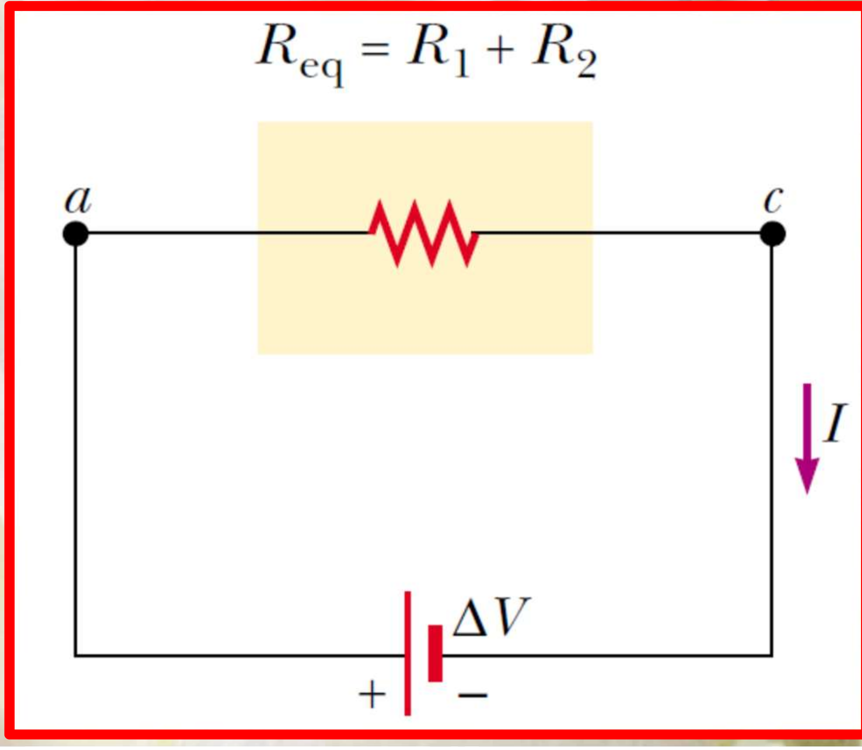
$$V = V_1 + V_2$$

$$R_{eq} I = R_1 I + R_2 I = (R_1 + R_2) I$$

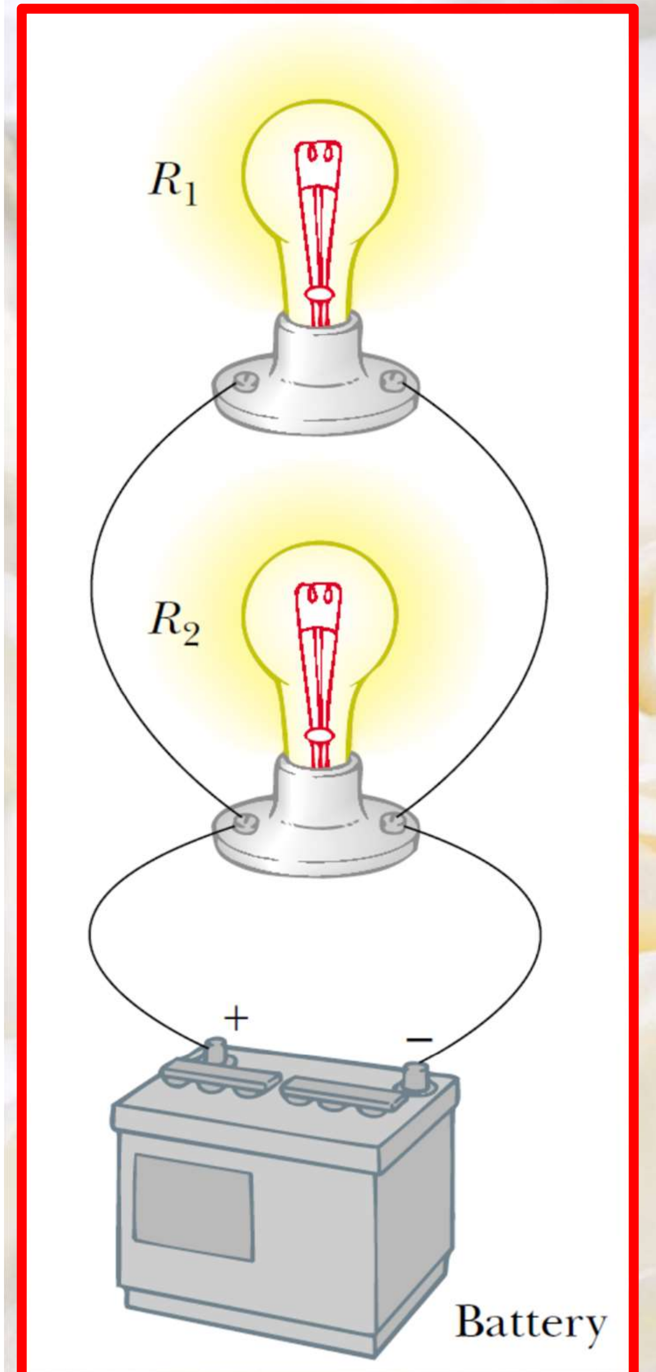
$$R_{eq} = R_1 + R_2$$

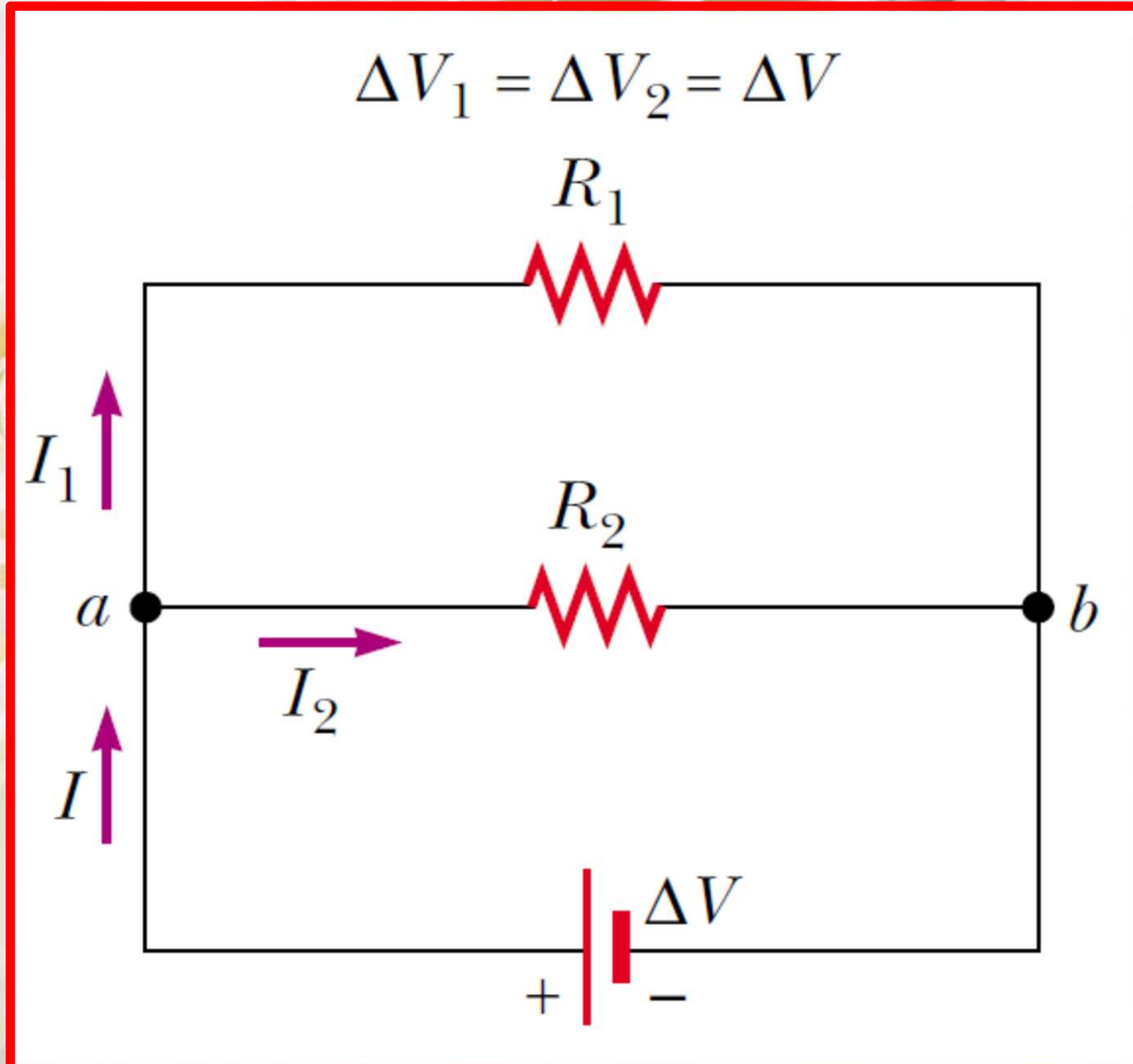
$$R_{eq} = R_1 + R_2 + R_3 + \cdots$$





به هم بستن موازی مقاومتها





$$I = I_1 + I_2$$

$$V = V_1 = V_2$$

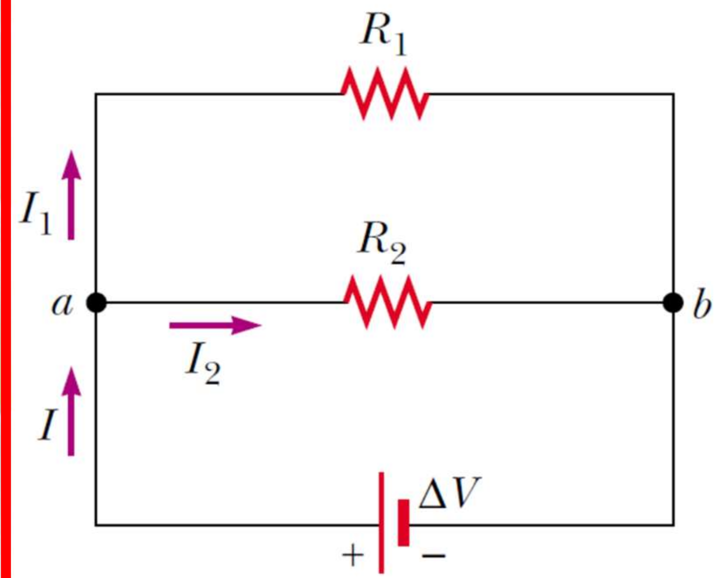
$$I = \frac{V}{R_{eq}} \qquad I_1 = \frac{V}{R_1} \qquad I_2 = \frac{V}{R_2}$$

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

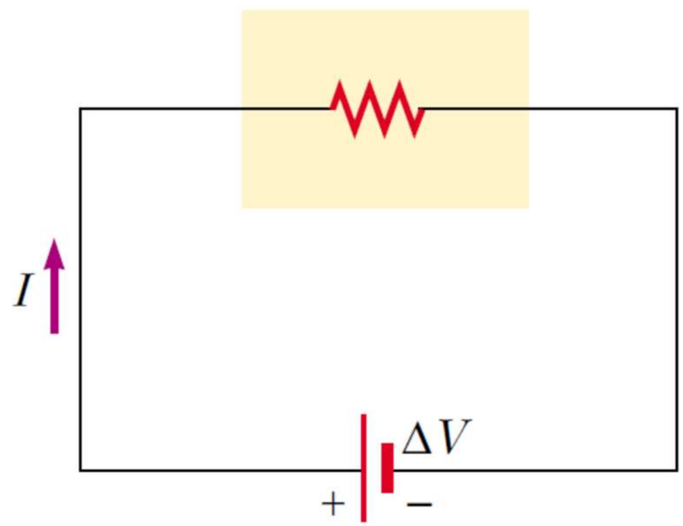
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

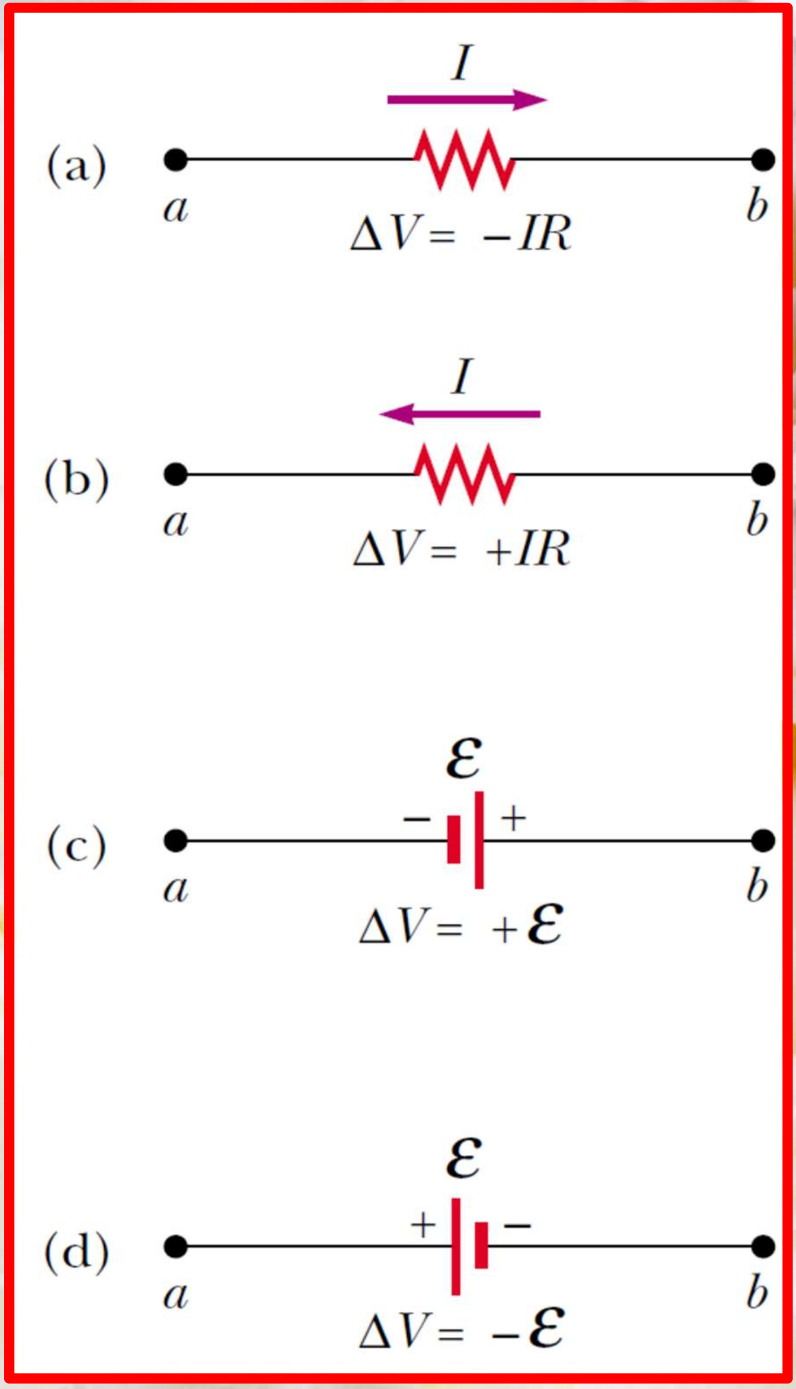
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$$

$$\Delta V_1 = \Delta V_2 = \Delta V$$



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



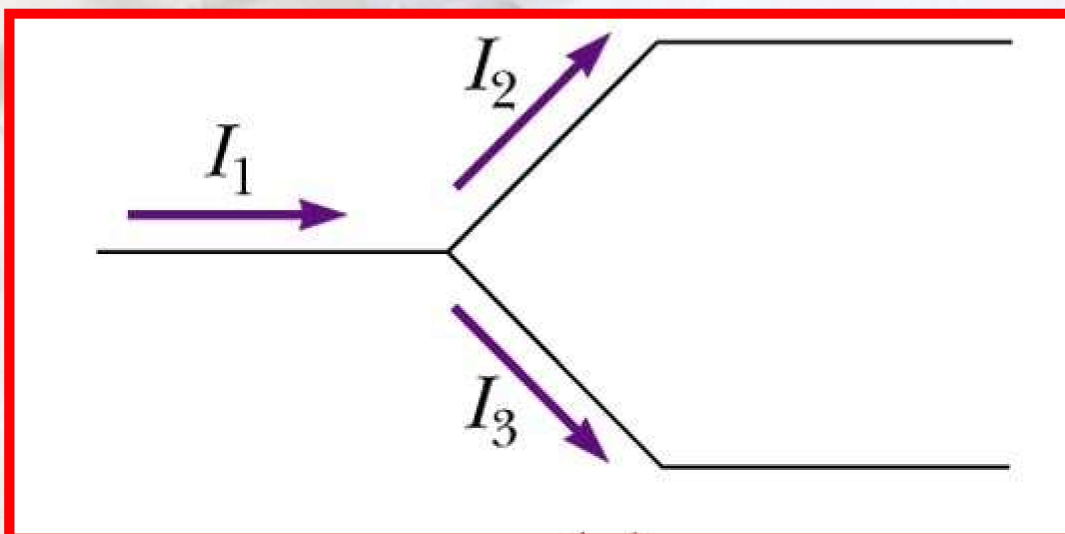


(a)
I
a
b
ΔV = −IR
(b)
I
a
b
ΔV = +IR
(c)
ℰ
− +
a
b
ΔV = +ℰ
(d)
ℰ
+ −
a
b
ΔV = −ℰ

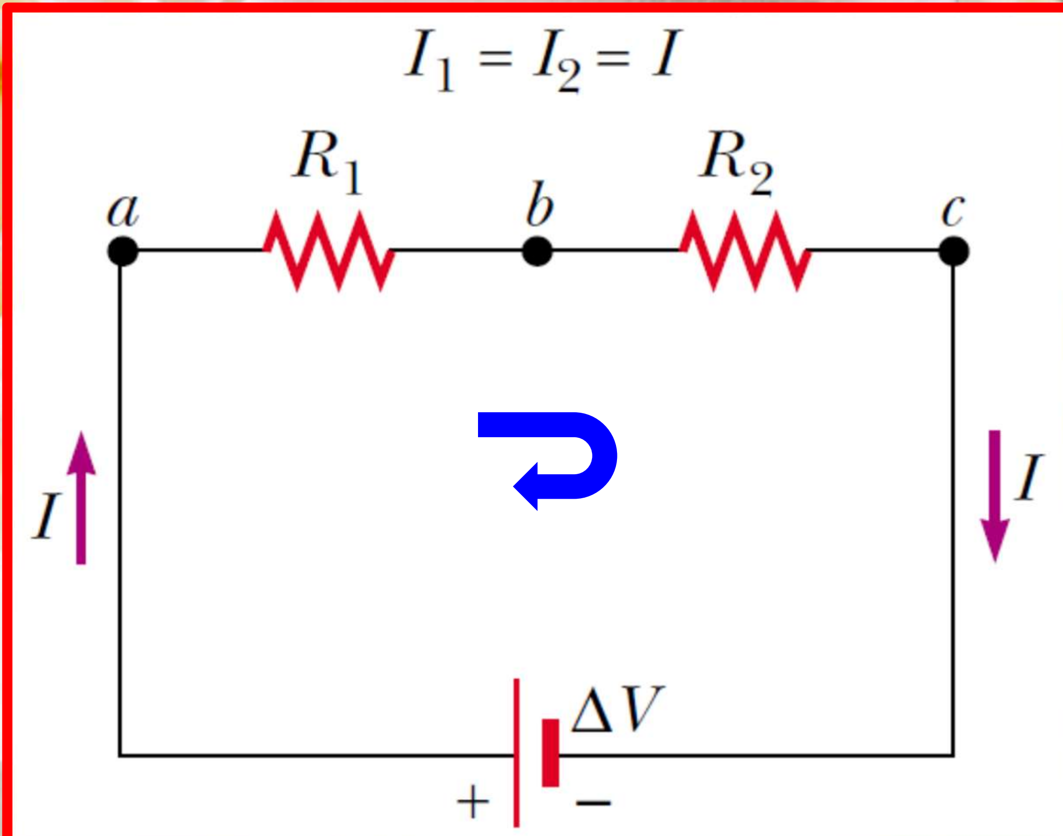
$$\sum I = 0$$

$$-I_1 + I_2 + I_3 = 0$$

$$I_1 = I_2 + I_3$$



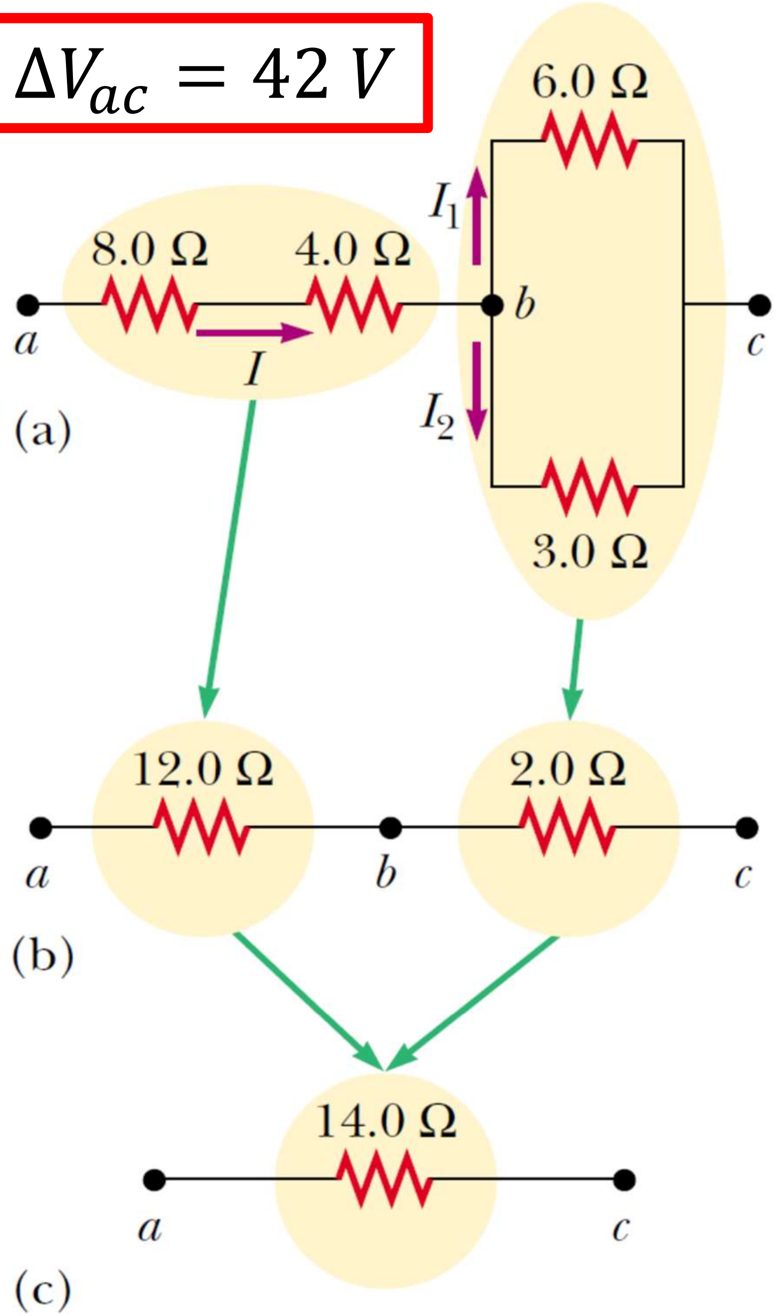
$$\sum_{\text{loop}} V = 0$$



$$V - IR_1 - IR_2 = 0$$

$$V = I\left(R_1 + R_2\right)$$

$$\Delta V_{ac} = 42\ V$$



$$I = \frac{\Delta V_{ac}}{R_{\text{eq}}} = \frac{42\ \text{V}}{14.0\ \Omega} = 3.0\ \text{A}$$

$$I = I_1 + I_2 = 3$$

$$V_{ac} = V_{ab} + V_{bc}$$

$$V_{bc} = 6I_1 = 3I_2$$

$$2I_1 = I_2$$

$$I = I_1 + 2I_1 = 3I_1 = 3$$

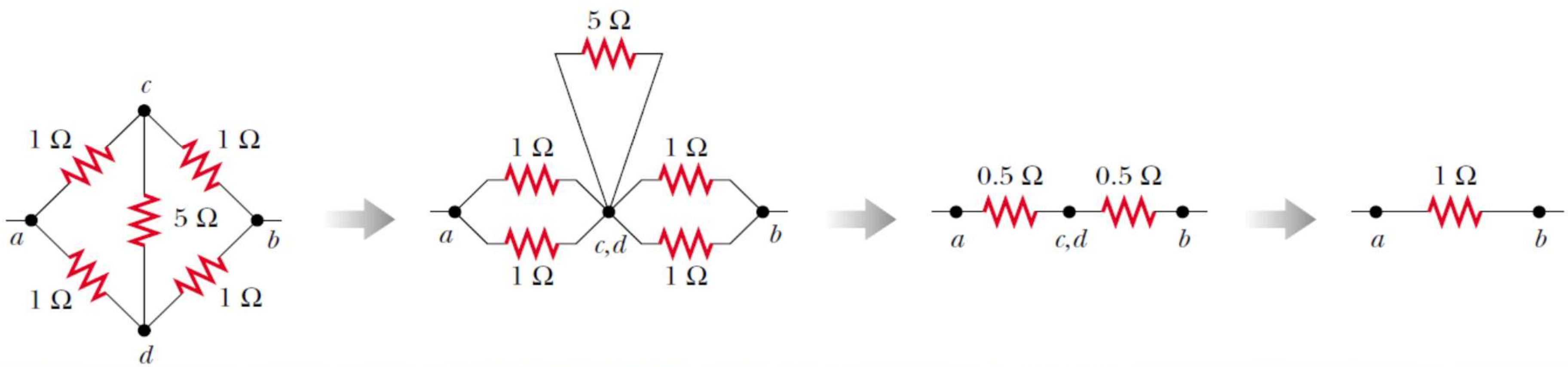
$$I_1 = 1 \qquad I_2 = 2$$

$$V_{ab} = 12 \times 3 = 36$$

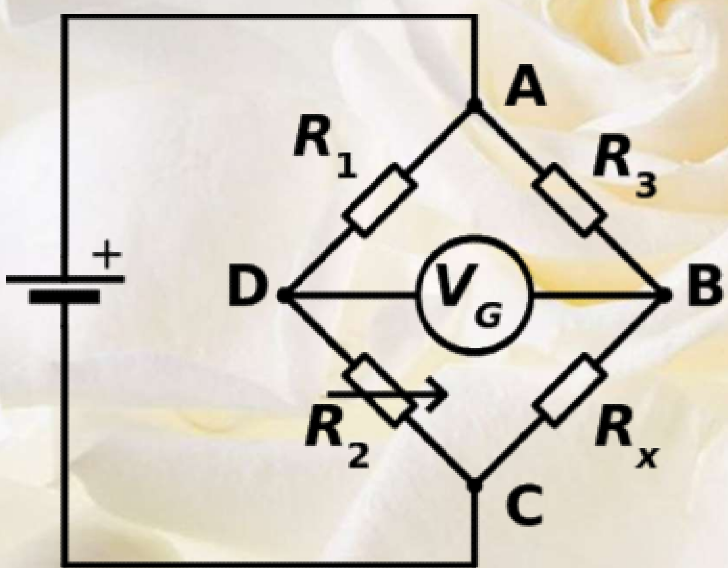
$$V_{bc} = 6 \times 1 = 3 \times 2 = 2 \times 3 = 6$$

$$V_{ac} = 36 + 6 = 42$$

مثال: مقاومت معادل مدار زیر را بیابید:



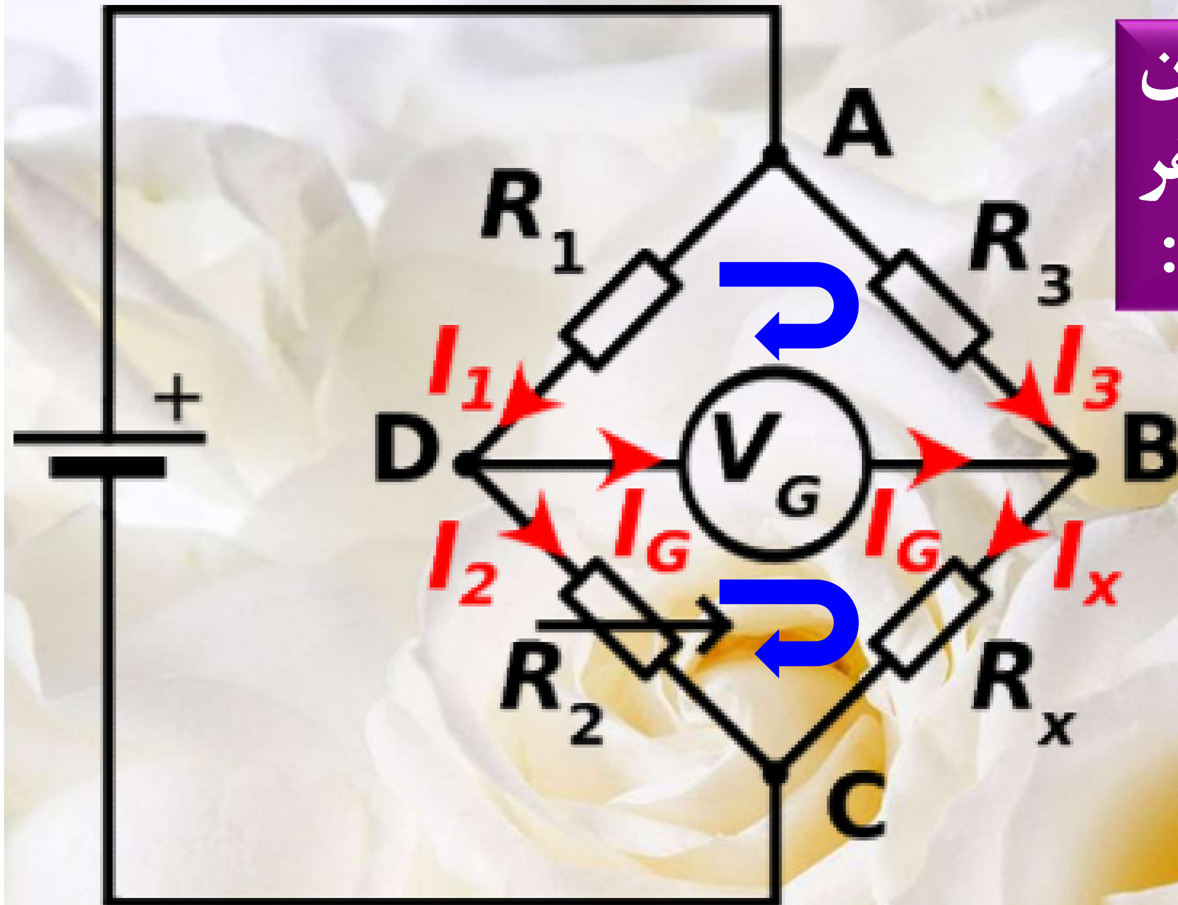
پل وتسون (Wheatstone bridge)



از پل وتسون برای تعیین مقاومت مجهول استفاده می شود

$$\frac{R_2}{R_1} = \frac{R_x}{R_3}$$

$$R_x = R_3 \frac{R_2}{R_1}$$



با تغییر مقاوت متغییر جریان عبوری از گالوانومتر را صفر می کنیم که در این صورت:

$V_D = V_B$ & $I_G = 0$

$I_3 = I_x$ & $I_1 = I_2$

$I_3 R_3 = I_1 R_1$

$I_x R_x = I_2 R_2$

$$\frac{R_2}{R_1} = \frac{R_x}{R_3}$$

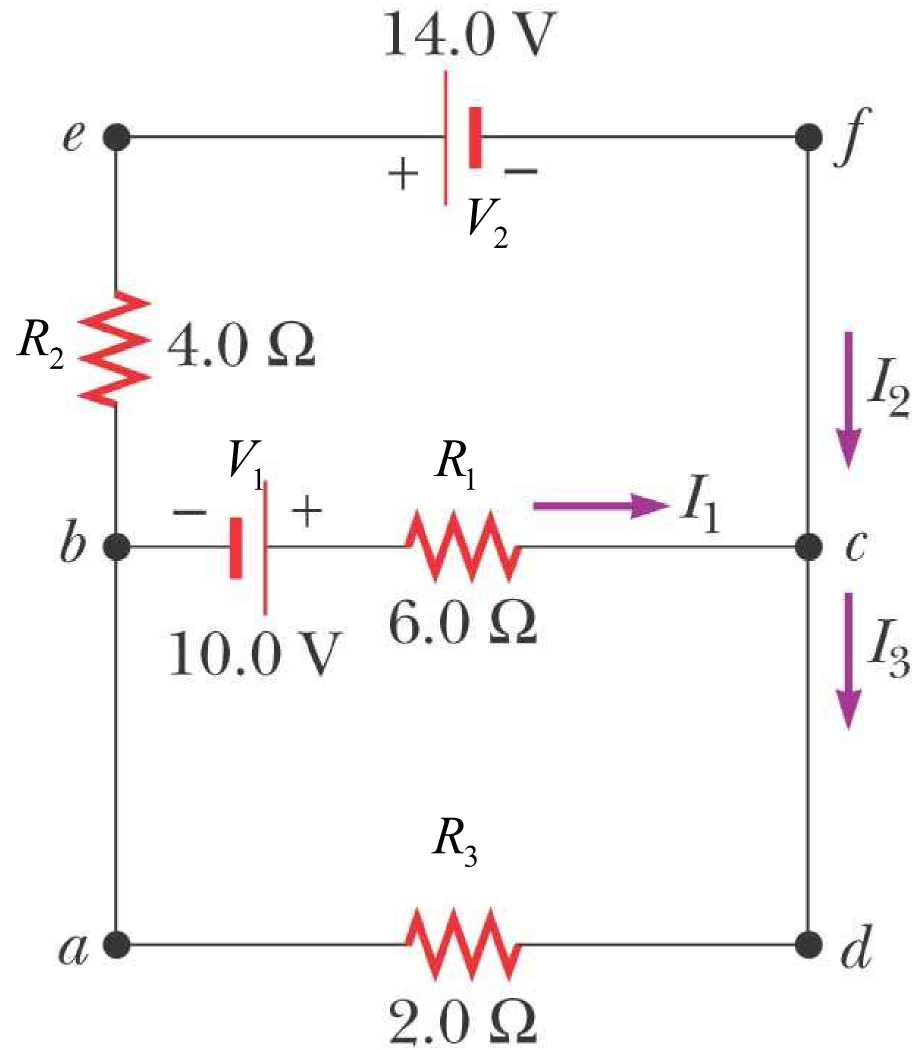
$$R_x = R_3 \frac{R_2}{R_1}$$

$At\ B:$ $I_3 - I_x + I_G = 0$

$At\ D:$ $I_1 - I_2 - I_G = 0$

$I_3 R_3 - I_G R_G - I_1 R_1 = 0$

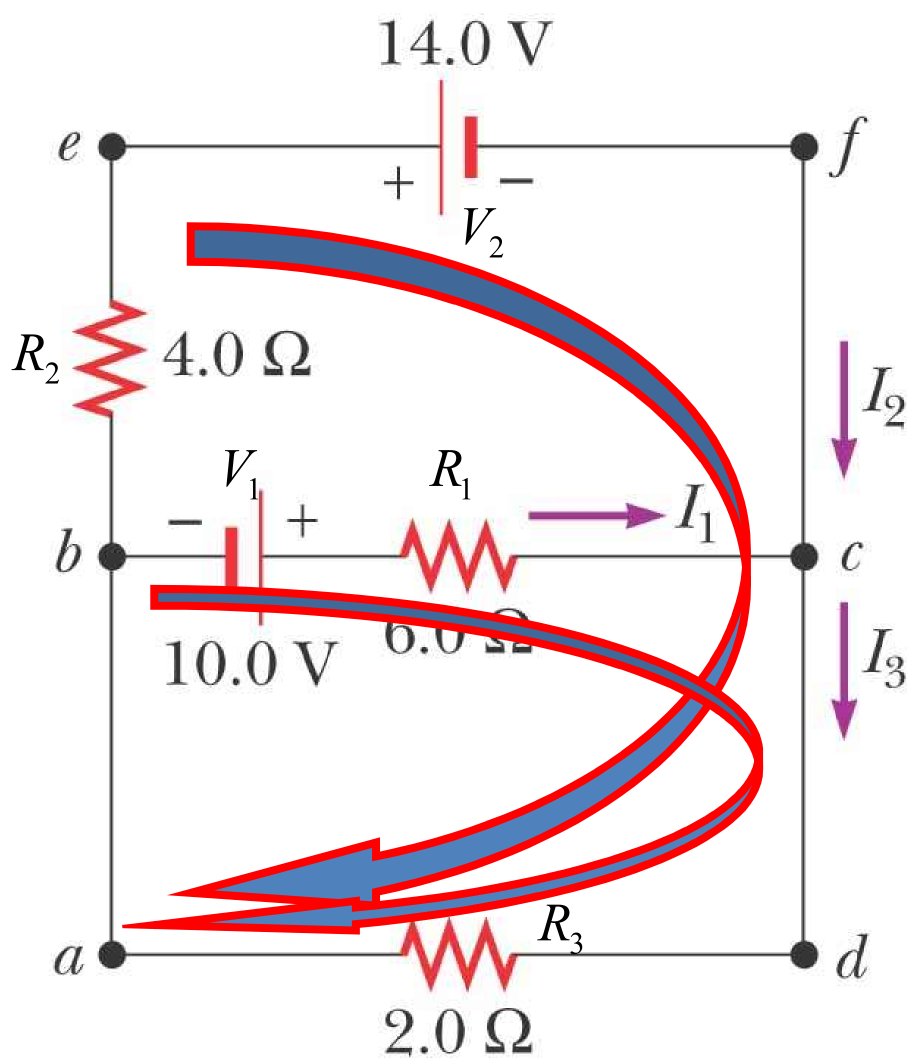
$I_x R_x - I_2 R_2 + I_G R_G = 0$


14.0 V
e
f
+
−
V2
R2
4.0 Ω
I2
V1
R1
−
+
I1
b
c
10.0 V
6.0 Ω
I3
R3
a
d
2.0 Ω

$\boxed{At\ C:}$ $\boxed{I_1 + I_2 = I_3}$

$$\boxed{-V_2 - I_3R_3 - I_2R_2 = 0}$$

$$\boxed{V_1 - I_1R_1 - I_3R_3 = 0}$$



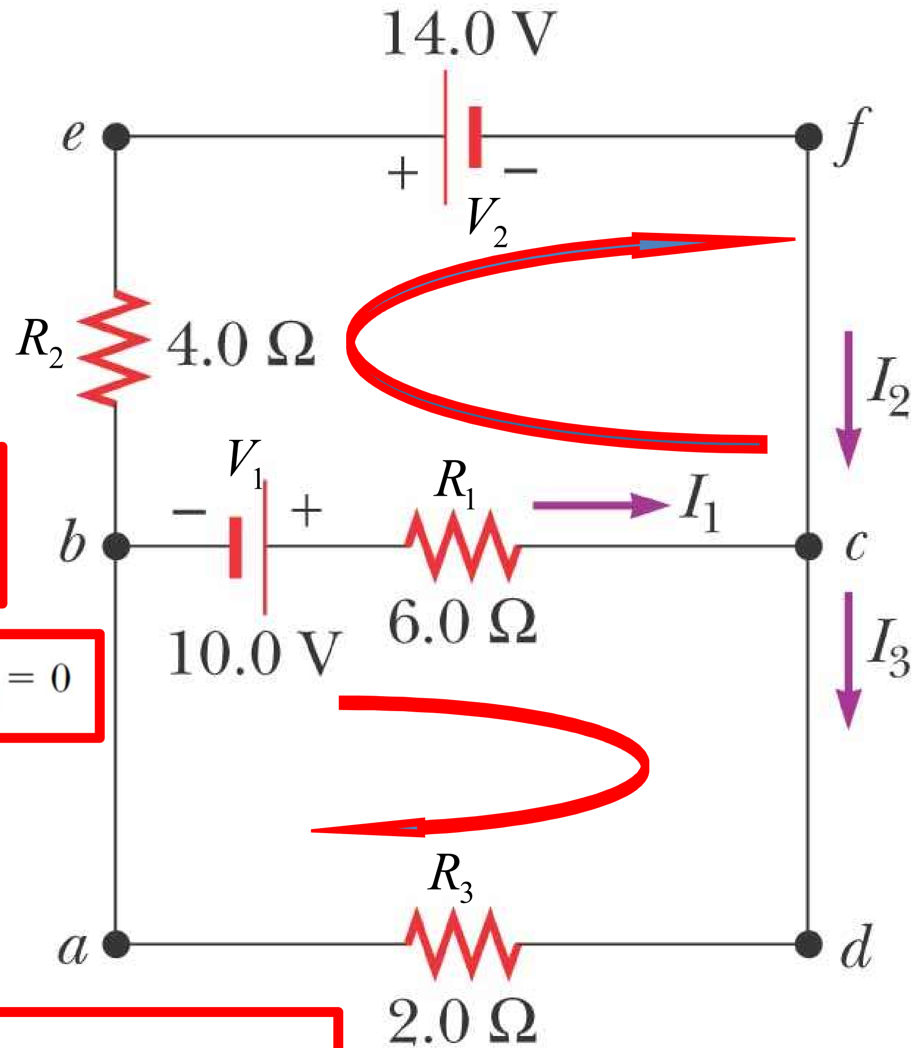
$\boxed{At\ C:}$

$$\boxed{I_1 + I_2 = I_3}$$

$$\boxed{-V_2 + I_1R_1 - V_1 - I_2R_2 = 0}$$

befcb $\quad -14.0\ \text{V} + (6.0\ \Omega)I_1 - 10.0\ \text{V} - (4.0\ \Omega)\ I_2 = 0$

$$\boxed{V_1 - I_1R_1 - I_3R_3 = 0}$$



abcda $\quad 10.0\ \text{V} - (6.0\ \Omega)I_1 - (2.0\ \Omega)I_3 = 0$

$\boxed{I_1 = 2\ A}$ $\boxed{I_2 = -3\ A}$ $\boxed{I_3 = -1\ A}$

At C:

$$I_1 + I_2 = I_3$$

defcd $\quad 4.00\ \text{V} - (3.00\ \Omega)I_2 - (5.00\ \Omega)I_3 = 0$

cfgbc $\quad (3.00\ \Omega)I_2 - (5.00\ \Omega)I_1 + 8.00\ \text{V} = 0$

$$I_2 = -\frac{4.00\ \text{V}}{11.0\ \Omega} = -0.364\ \text{A}$$

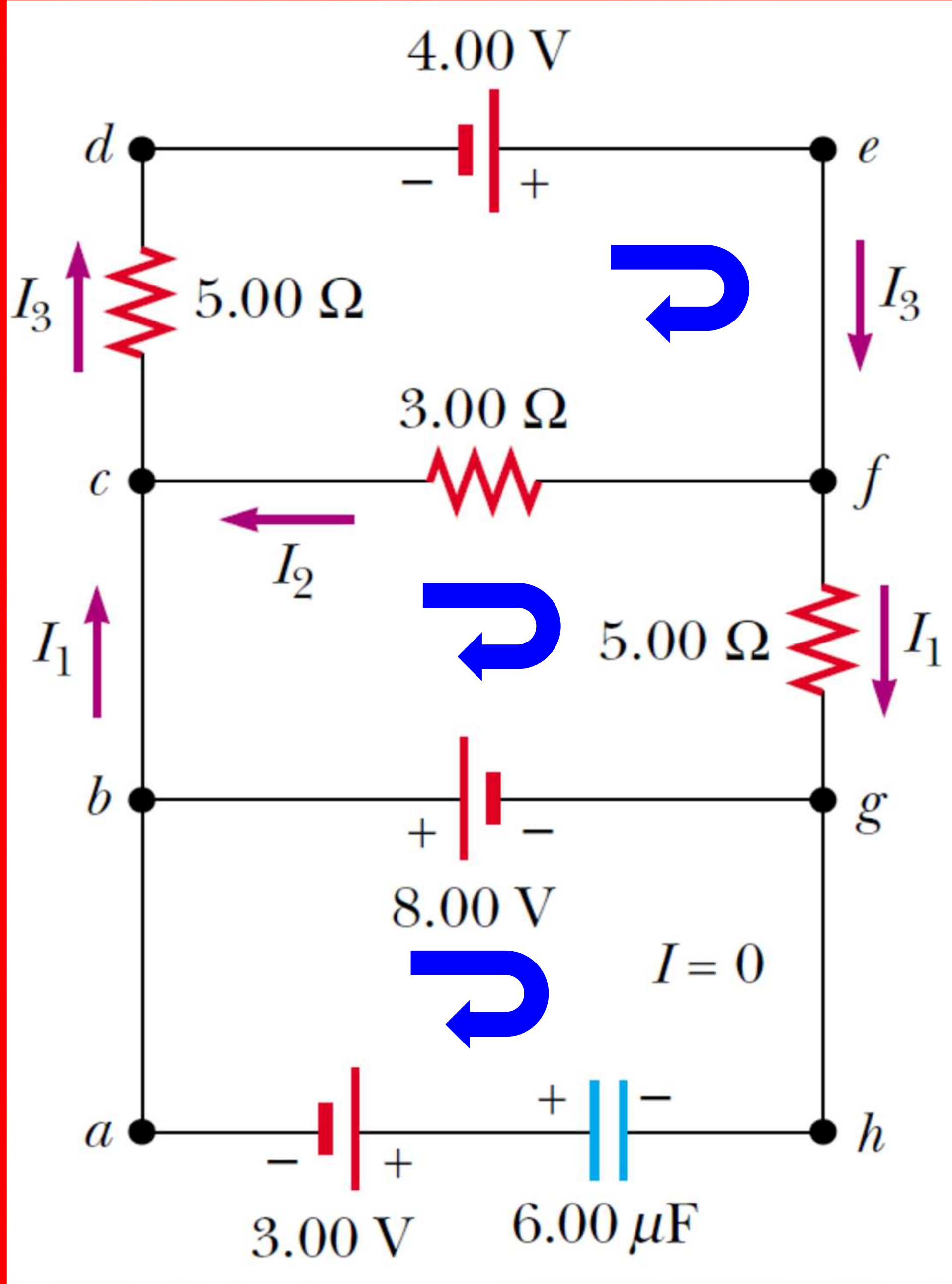
$I_1 = 1.38\ \text{A} \qquad I_3 = 1.02\ \text{A}$

$$-8.00\ \text{V} + \Delta V_{cap} - 3.00\ \text{V} = 0$$

$$\Delta V_{cap} = 11.0\ \text{V}$$

$$Q = C\,\Delta V_{cap}$$

$$Q = (6.00\ \mu\text{F})(11.0\ \text{V}) = 66.0\ \mu\text{C}$$



$$\varepsilon = \frac{q}{C} + IR$$

$$\frac{dq}{dt} = \frac{-q}{RC} + \frac{\varepsilon}{R}$$

$$\frac{dq}{dt} = \frac{-q + C\varepsilon}{RC}$$

$$\frac{dq}{q - C\varepsilon} = -\frac{dt}{RC}$$

$$\int \frac{dq}{q - C\varepsilon} = -\frac{1}{RC}\int dt$$

$$q - C\varepsilon = u$$

$$dq = du$$

$$\int \frac{du}{u} = -\frac{1}{RC} t$$

$$\ln u = -\frac{1}{RC} t + K$$

$$\ln(q - C\varepsilon) = -\frac{1}{RC} t + K$$

$$t = 0 \Rightarrow q = 0$$

$$\ln(-C\varepsilon) = K$$

$$\ln(q - C\varepsilon) = -\frac{1}{RC} t + \ln(-C\varepsilon)$$

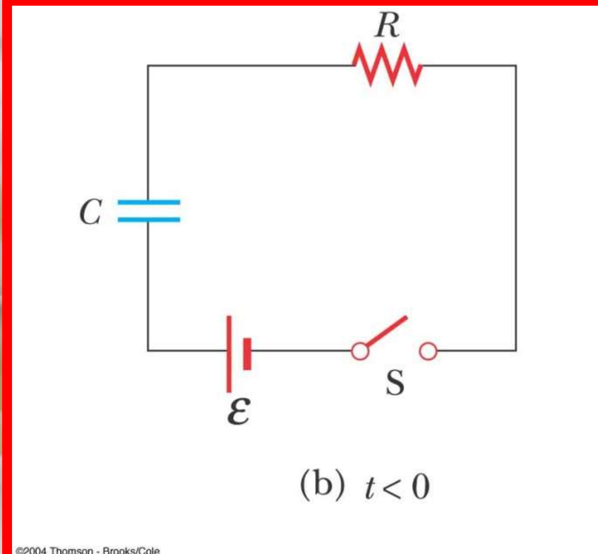
$$\ln\left(\frac{q - C\varepsilon}{-C\varepsilon}\right) = -\frac{1}{RC} t$$

$$\frac{q - C\varepsilon}{-C\varepsilon} = \exp\left(-\frac{t}{RC}\right)$$

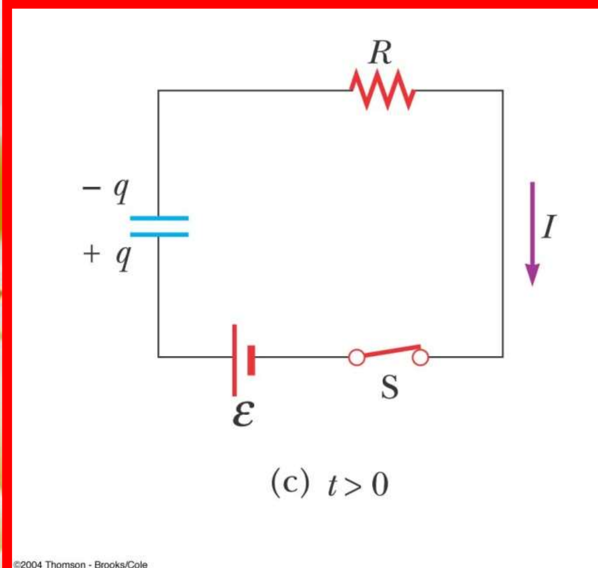
$$q - C\varepsilon = -C\varepsilon \exp\left(-\frac{t}{RC}\right)$$

$$q = C\varepsilon\left(1 - \exp\left(-\frac{t}{RC}\right)\right)$$

$$q = Q\left(1 - \exp\left(-\frac{t}{RC}\right)\right)$$



(b) $t < 0$

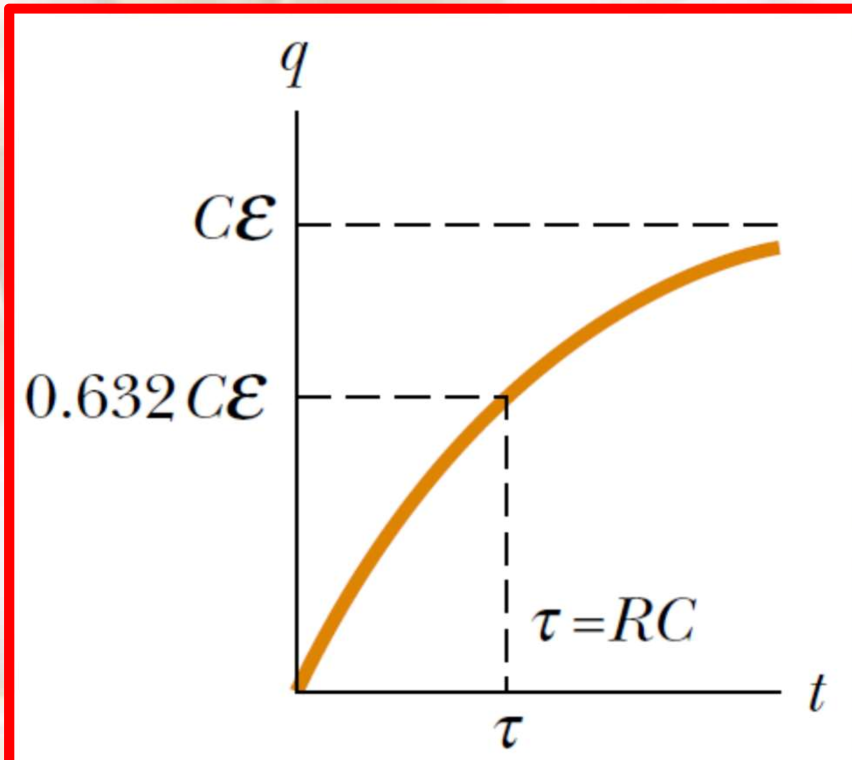


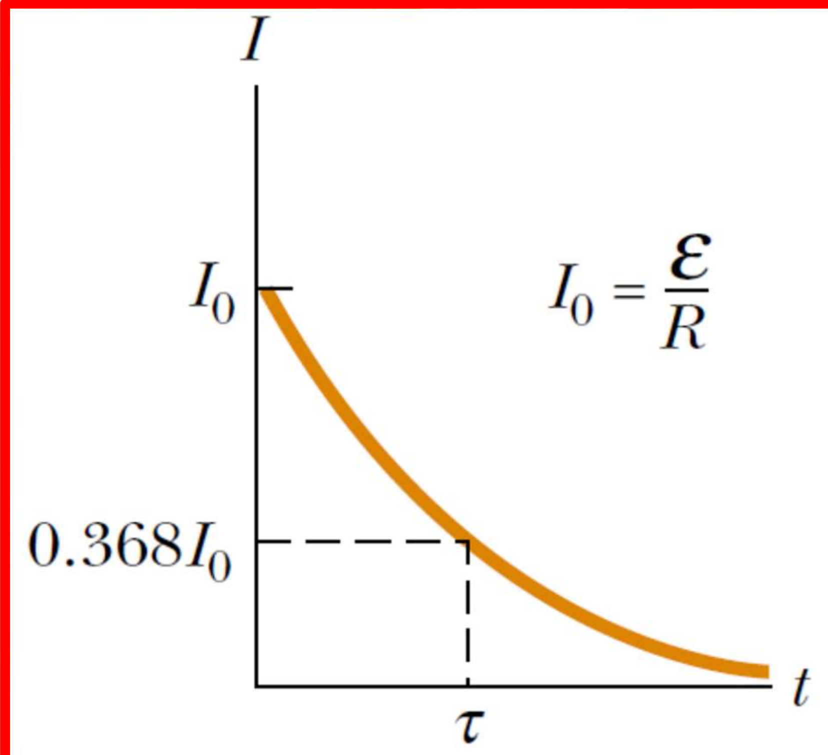
(c) $t > 0$

$$I = \frac{dq}{dt} = \frac{Q}{RC} e^{-t/RC} = I_0 e^{-t/RC}$$

$$q = Q\left(1 - \exp\left(-\frac{t}{RC}\right)\right)$$

$$I = I_0 \exp\left(-\frac{t}{RC}\right)$$





$$V=\frac{q}{C}=-IR$$

$$I=\frac{dq}{dt}=\frac{-q}{RC}$$

$$\frac{dq}{q}=\frac{-1}{RC}dt$$

$$\ln q=\frac{-1}{RC}t+K$$

$$\ln Q=\frac{-1}{RC}(0)+K$$

$$\ln Q=K$$

$$\ln q=\frac{-1}{RC}t+\ln Q$$

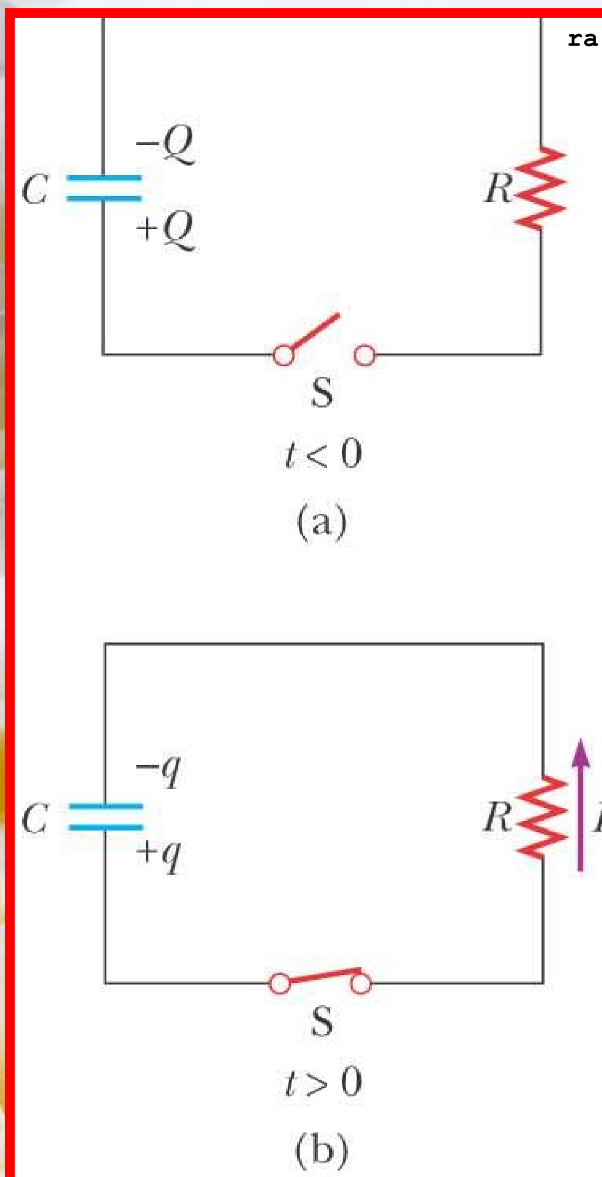
$$\ln q-\ln Q=\frac{-1}{RC}t$$

$$\ln\frac{q}{Q}=\frac{-1}{RC}t$$

$$q=Q\exp\left(\frac{-t}{RC}\right)$$

$$I=\frac{dq}{dt}$$

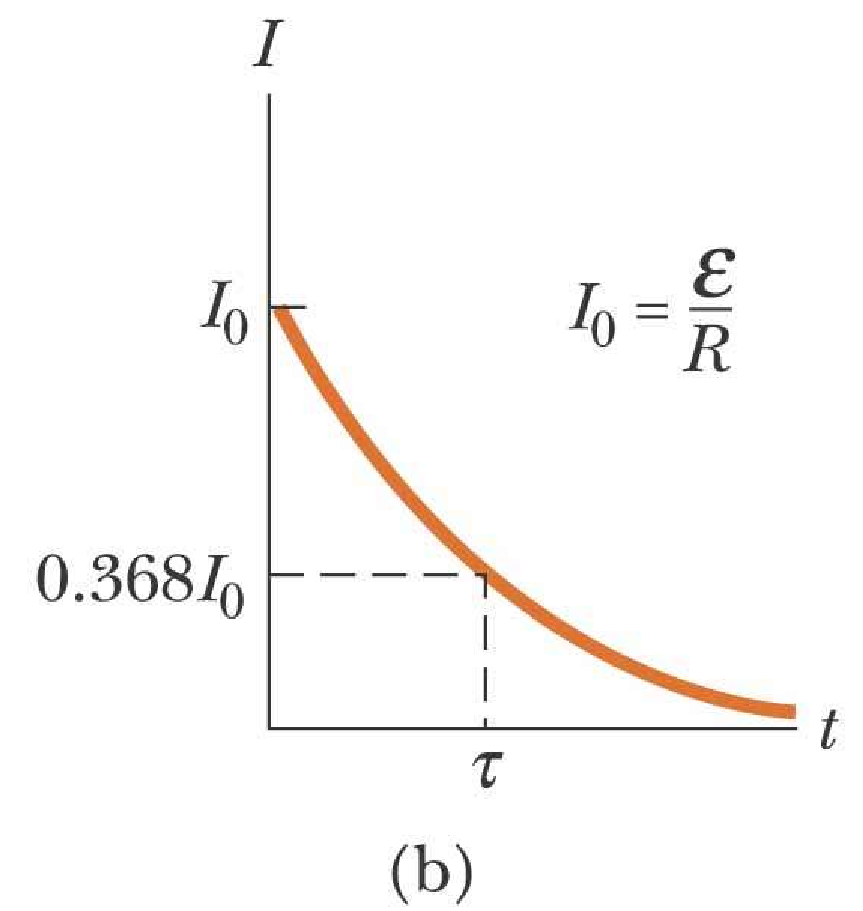
$$I=-\frac{Q}{RC}\exp\left(\frac{-t}{RC}\right)$$



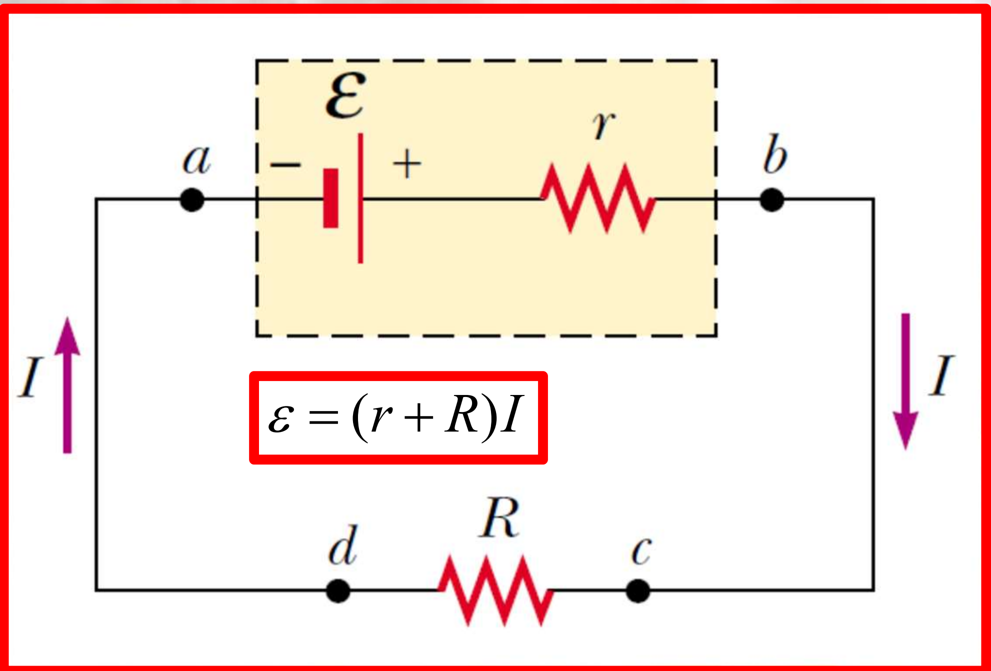
$$|I| = \frac{Q}{RC}\exp\left(\frac{-t}{RC}\right)$$

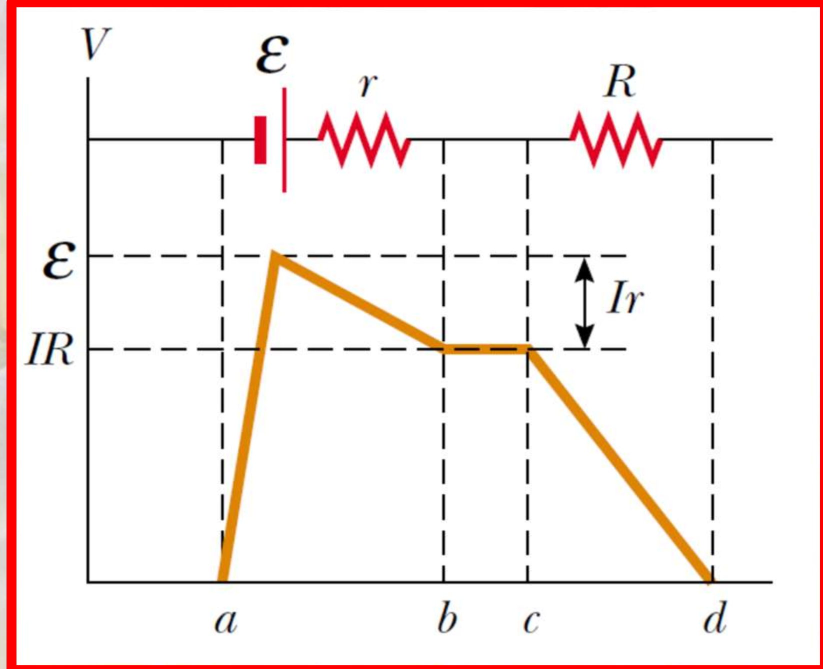
$$|I| = I_0 \exp\left(\frac{-t}{\tau}\right)$$

$$\tau = RC$$



باطری ها در عمل دارای مقاومت داخلی هستند





سوال: روشنایی ماکزیمم با یک باطری دارای مقاومت داخلی چه وقت حاصل می شود؟

پاسخ: وقتی که توان ماکزیمم شود

$$P = RI^2$$

$$\varepsilon = (r+R)I$$

$$I = \frac{\varepsilon}{r+R}$$

$$P = R\left(\frac{\varepsilon}{r+R}\right)^2$$

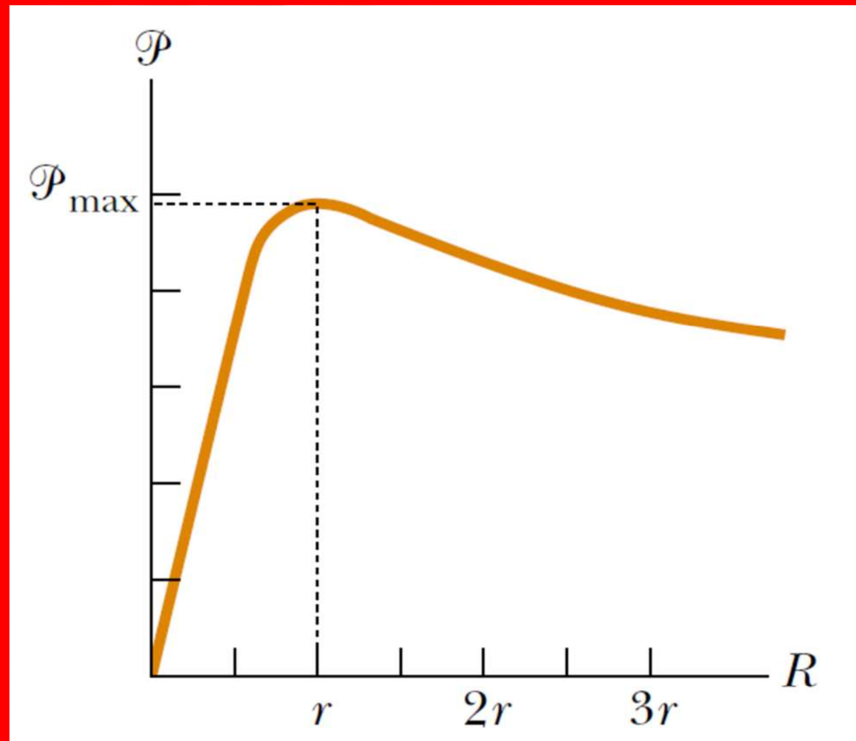
$$\frac{dP}{dR} = \left(\frac{\varepsilon}{r+R}\right)^2 + R \times 2 \times \frac{0-\varepsilon}{(r+R)^2}\frac{\varepsilon}{r+R} = 0$$

$$\frac{\varepsilon}{r+R} = 2R\frac{\varepsilon}{(r+R)^2}$$

$$1 = 2R\frac{1}{r+R}$$

$$2R = r+R$$

$$R = r$$



$$P_{max} = rI^2 = r\left(\frac{\varepsilon}{2r}\right)^2 = \frac{1}{4}\frac{\varepsilon^2}{r}$$