Capacitors

Capacitors

- Store Electrical Potential Energy AND Charge.

$$Q = CV$$

$$C = \varepsilon_o \frac{A}{d} \qquad \varepsilon_o = 8.85x10^{-12}$$

$$C = K\left(\varepsilon_o \frac{A}{d}\right) = \varepsilon \frac{A}{d} \qquad \varepsilon = K\varepsilon_o$$

K=1.000 ---> 300+

Capacitors

- What is the spacing between the plates of a 150 uF, if the plates are 20.0 cm x 30.0 cm

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

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

$$d = \left(8.85x10^{-12}\right)\frac{\left(0.2m * 0.3m\right)}{150x10^{-6}} = 3.5x10^{-9}m$$

Capacitors

- What is the charge stored on a 150 uF, if the plates are connected to a 5 V battery

$$Q = CV$$

$$Q = \left(150\mu F\right)\left(5\text{V}\right)$$

$$Q = 0.00075 \text{ Coulombs}$$

Capacitors: Energy

- What is the energy stored on capacitors

$$PE = \frac{1}{2}QV$$

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

$$PE = \frac{1}{2}\frac{Q^2}{C}$$

Capacitors

- What is the energy stored on a 150 uF capacitor, if the plates are connected to a 5 V battery

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

$$PE = \frac{1}{2}\left(150\mu F\right)\left(5\text{V}\right)^2$$

$$PE = 0.001875\ \text{J}$$

Capacitors

- What is the energy stored on a capacitor if the plates hold 0.00075 C of charged are connected to a 5 V battery

$$PE = \frac{1}{2}QV$$

$$PE = \frac{1}{2}\left(0.00075C\right)\left(5\text{V}\right)$$

$$PE = 0.001875\ \text{J}$$

Capacitors

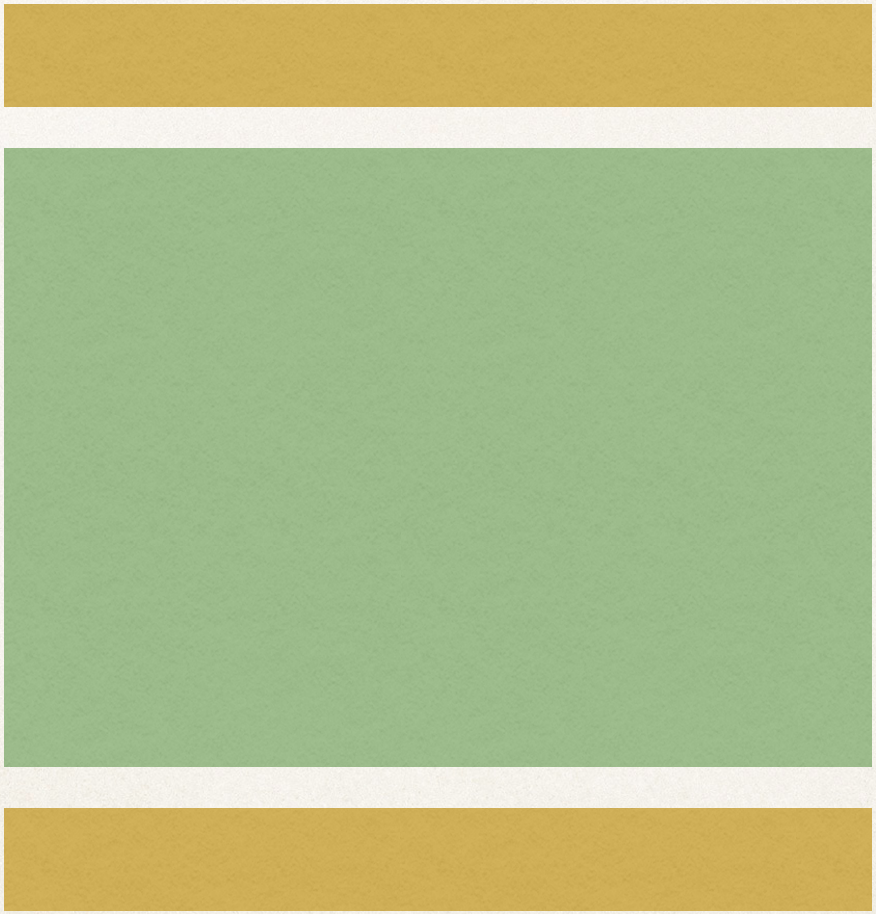
- What is the energy stored on a 150 uF capacitor, if the plates hold 0.00075C of charge.

$$PE = \frac{1}{2}\frac{Q^2}{C}$$

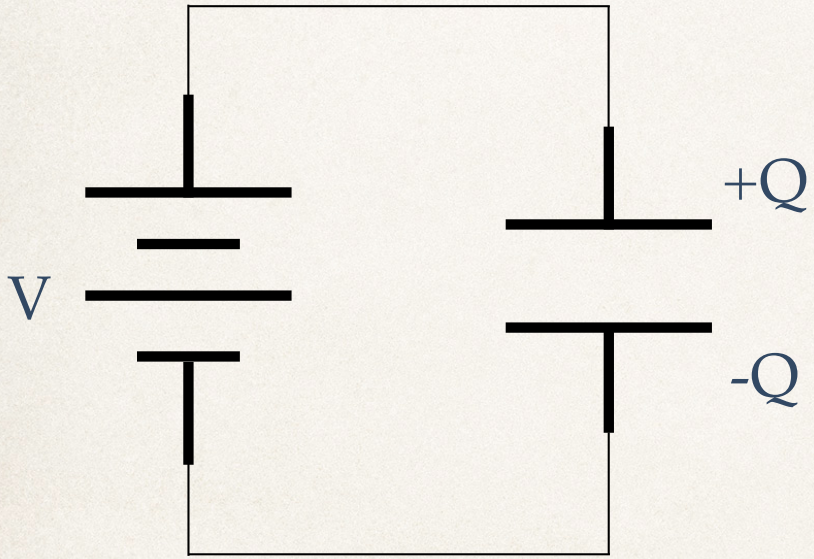
$$PE = \frac{1}{2}\frac{\left(0.00075C\right)^2}{\left(150\mu F\right)}$$

$$PE = 0.001875\ \text{J}$$

Capacitors

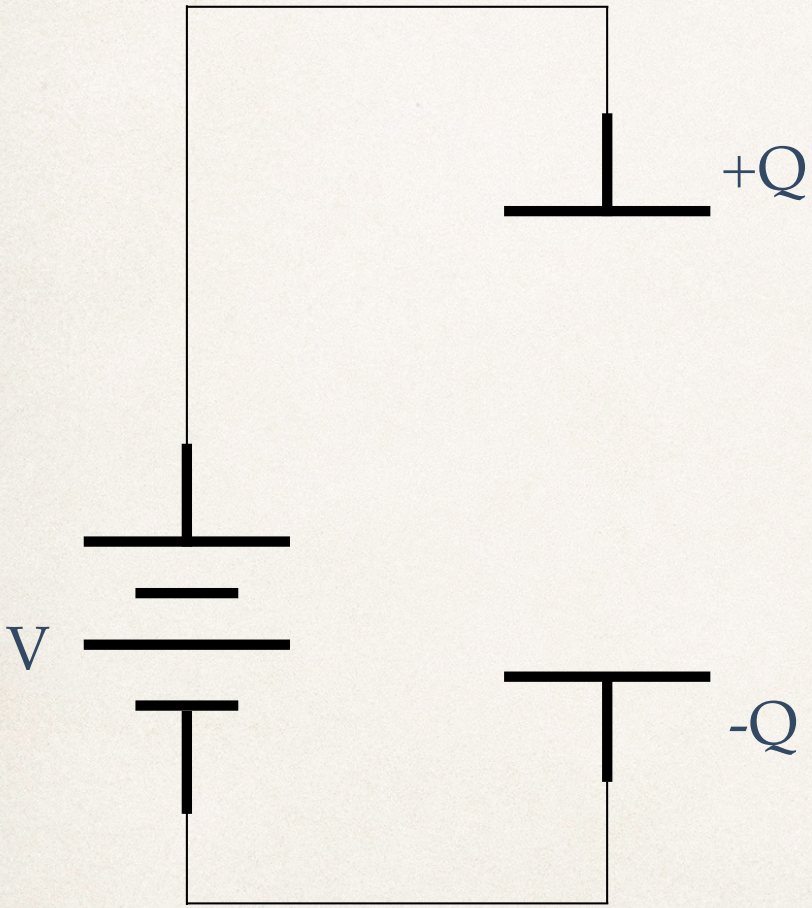


Capacitors in series



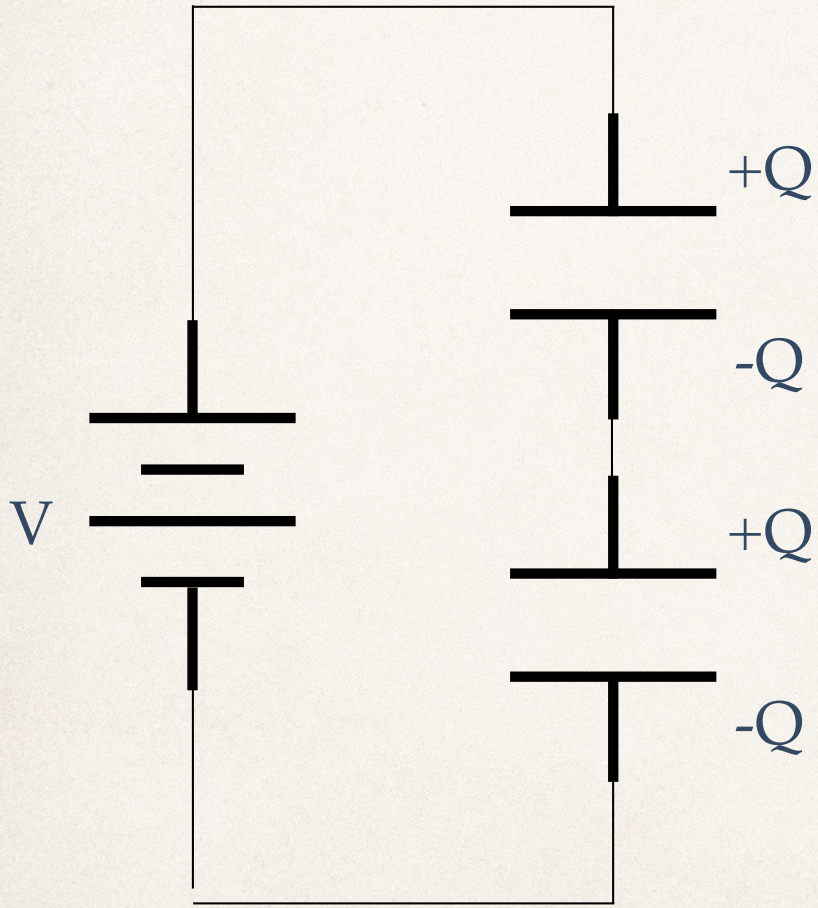
$$Q = CV$$

Capacitors in series



$$Q = CV$$

Capacitors in series



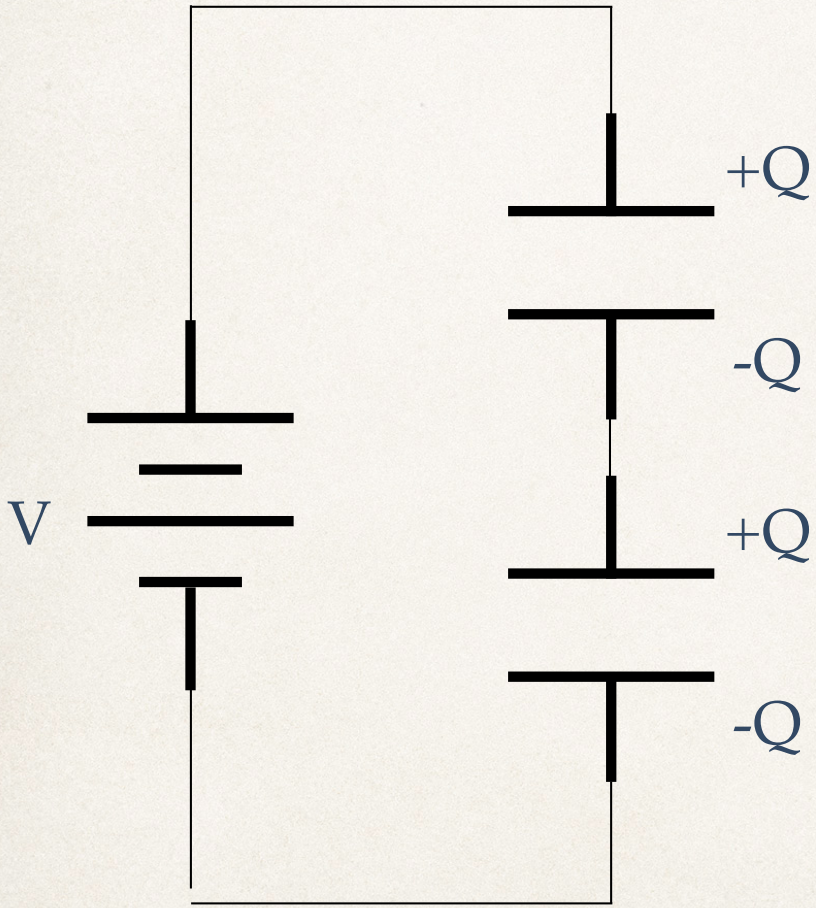
$$V = \frac{Q}{C}$$

$$V = V_1 + V_2$$

$$\frac{Q_{total}}{C_{total}} = \frac{Q_1}{C_1} + \frac{Q_2}{C_2}$$

but… $Q_{total} = Q_1 = Q_2$

Capacitors in series



so…

$$\frac{Q}{C_{total}} = \frac{Q}{C_1} + \frac{Q}{C_2}$$

$$\boxed{\frac{1}{C_{total}} = \frac{1}{C_1} + \frac{1}{C_2}}$$

Series Capacitors

- What is the total capacitance of the following capacitors connected in series: 150 nF, 300 nF, 450 nF

$$\frac{1}{C_{total}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\frac{1}{C_{total}} = \frac{1}{150x10^{-9}F} + \frac{1}{300x10^{-9}F} + \frac{1}{450x10^{-9}F}$$

$$\frac{1}{C_{total}} = 6.67x10^{7}\,\frac{1}{F} + 3.33x10^{7}\,\frac{1}{F} + 2.22x10^{7}\,\frac{1}{F}$$

Series Capacitors

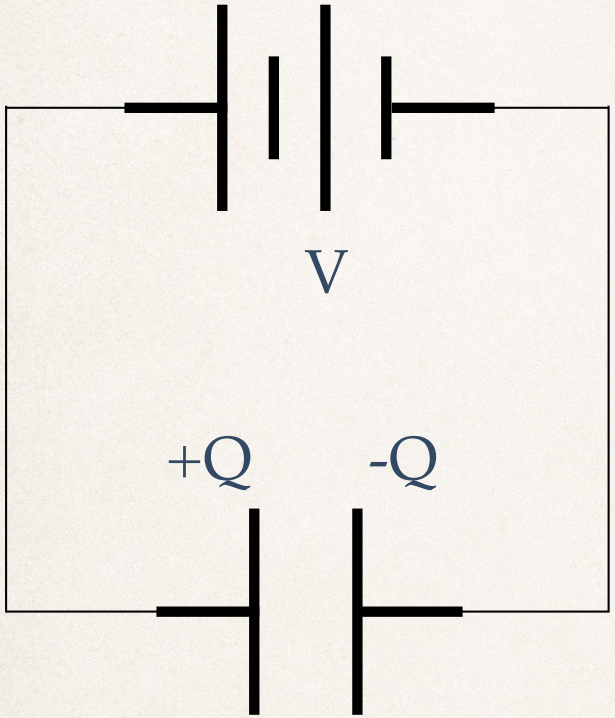
- What is the total capacitance of the following capacitors connected in series: 150 nF, 300 nF, 450 nF

$$\frac{1}{C_{total}} = 12.22x10^{7}\,\frac{1}{F}$$

$$C_{total} = \frac{1}{12.22x10^{7}\,\frac{1}{F}}$$

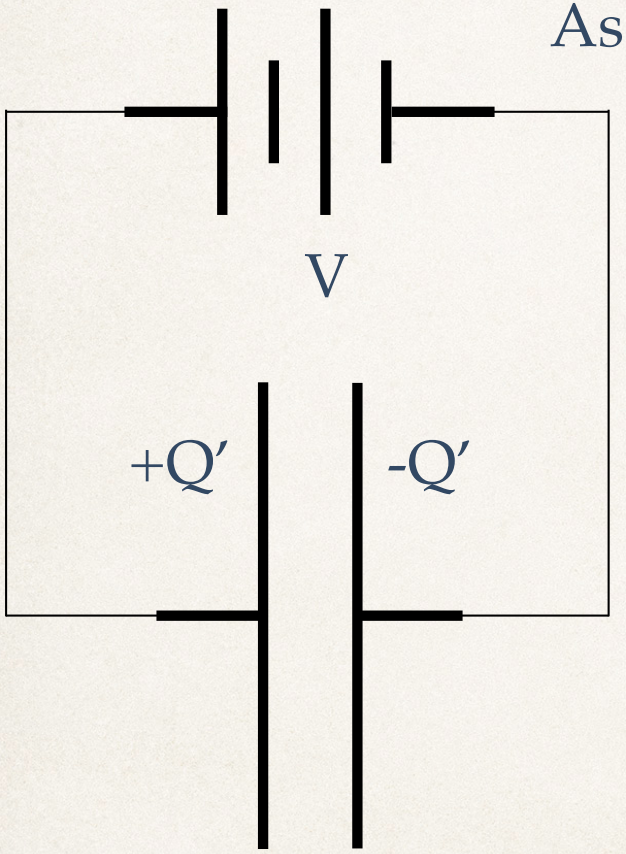
$$C_{total} = 8.18x10^{-9}\,F = 8.18\ nF$$

Capacitors in parallel



$$Q = CV$$

Capacitors in parallel



Assume plates are twice as big as previous example

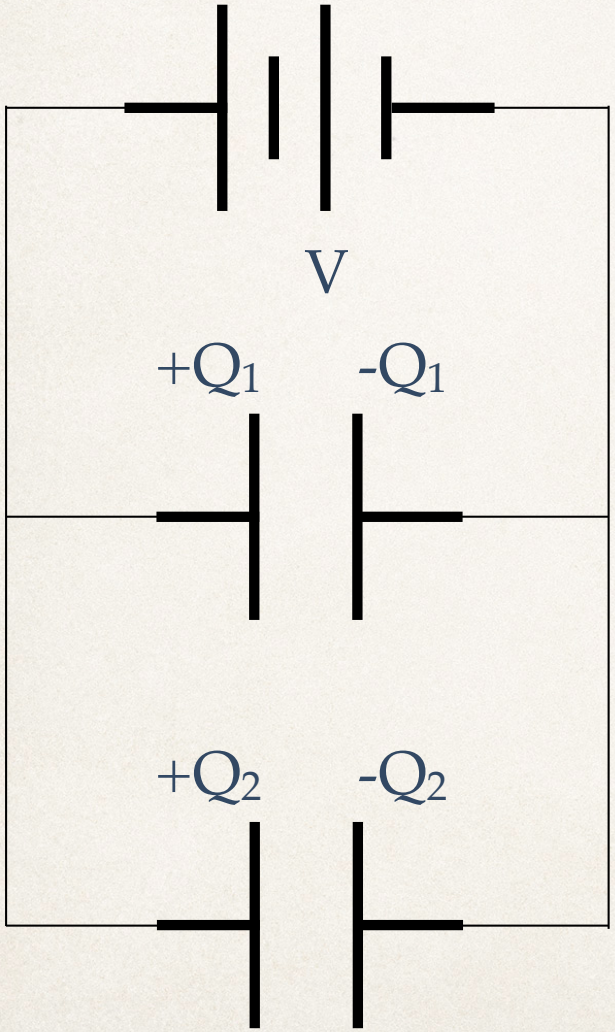
$$Q = \varepsilon_o \frac{A}{d}$$

$$Q' = \varepsilon_o \frac{A'}{d} \qquad \text{but} \qquad A' = 2A$$

$$Q' = \varepsilon_o \frac{2A}{d} \qquad Q' = 2\left(\varepsilon_o \frac{A}{d}\right)$$

$$\therefore \qquad \boxed{Q' = 2Q}$$

Capacitors in parallel



$$Q_{total} = Q_1 + Q_2$$

$$C_{total} V_{total} = C_1 V_1 + C_2 V_2$$

but… $$V_{total} = V_1 + V_2$$

so… $$\boxed{C_{total} = C_1 + C_2}$$

Parallel Capacitors

- What is the total charge stored on the following capacitors connected in parallel, if connected to a 12V battery?: 150 nF, 300 nF, 450 nF

$$C_{total} = C_1 + C_2 + C_3$$

$$C_{total} = 150\ \text{nF} + 300\ \text{nF} + 450\ \text{nF}$$

$$C_{total} = 900\ \text{nF}$$

Parallel Capacitors

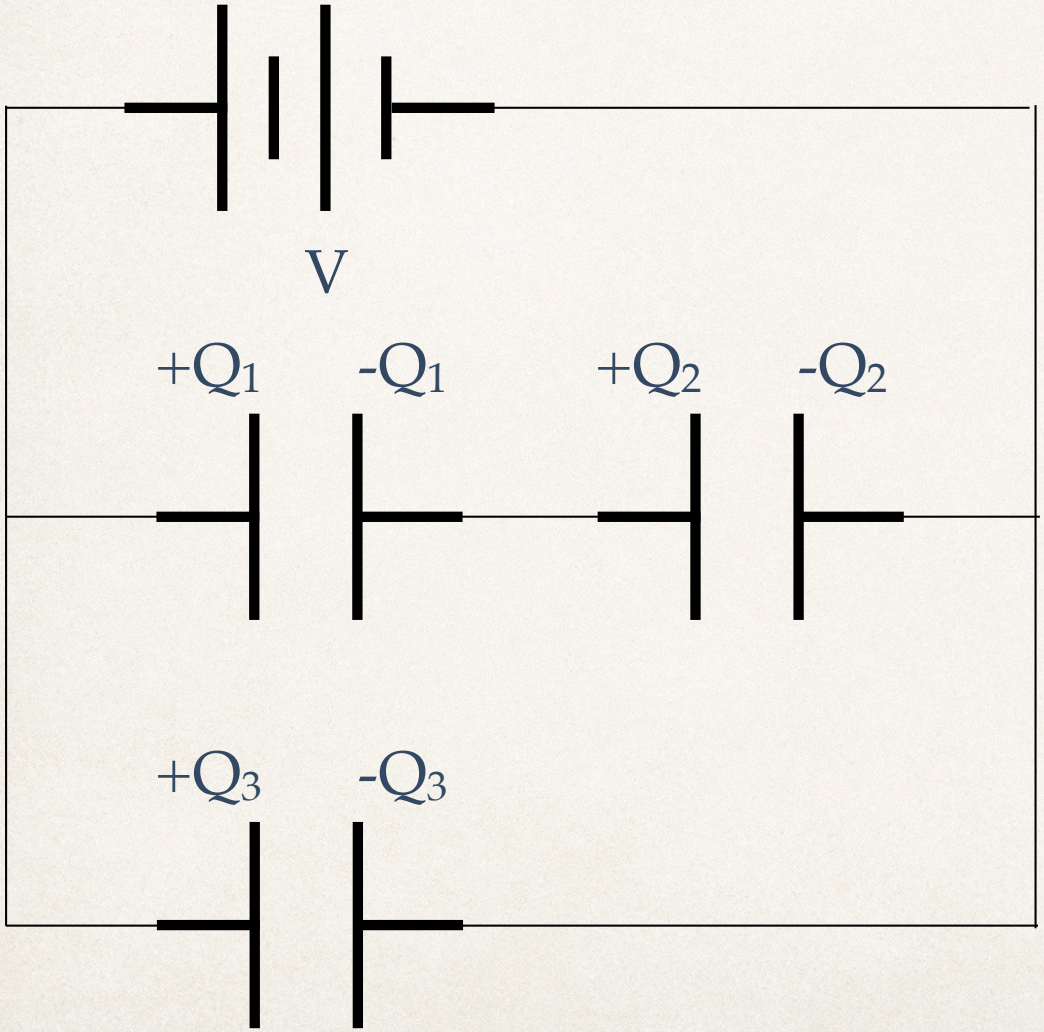
- What is the total charge stored on the following capacitors connected in parallel, if connected to a 12V battery?: 150 nF, 300 nF, 450 nF

$$Q = CV$$

$$Q = \left(900x10^{-9}\ \text{F}\right)\left(12\ \text{V}\right)$$

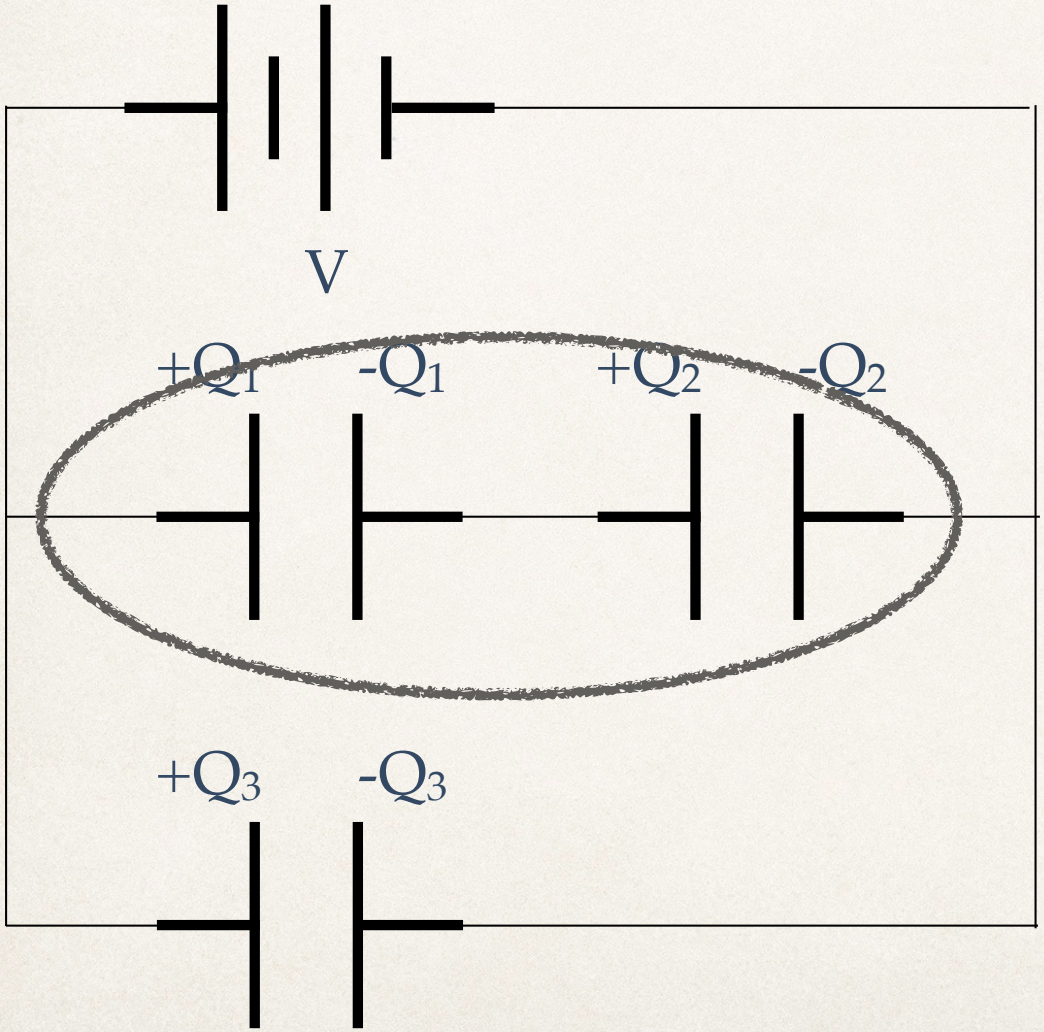
$$Q = 10.8\ \mu\text{C}$$

Equivalent Capacitance



- What is the total charge stored on the following capacitors connected in parallel, if connected to a 12V battery?: C_1=150 nF, C_2=300 nF, C_3=450 nF

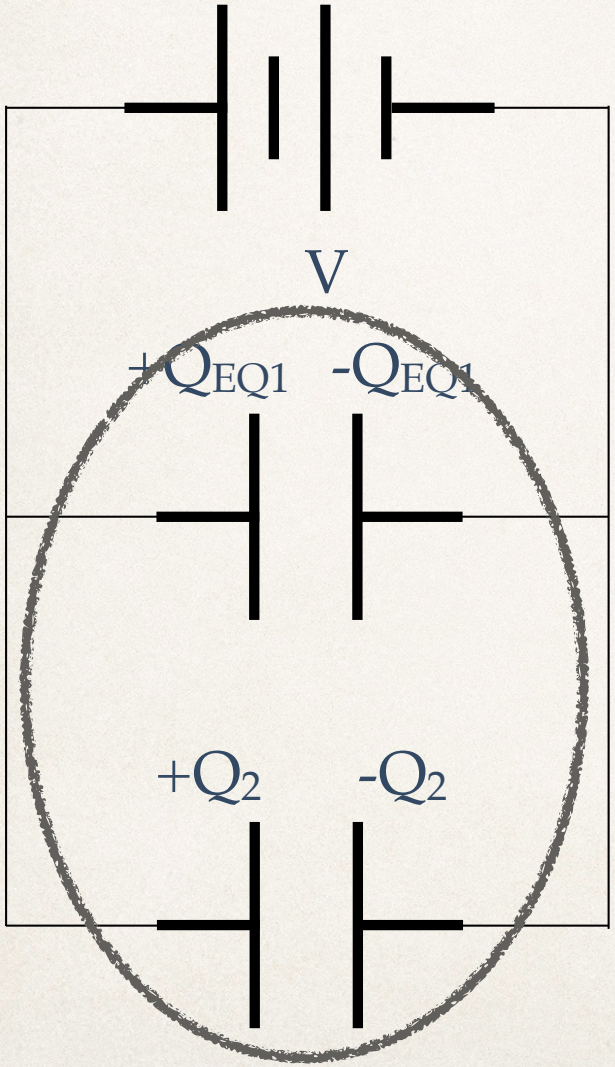
Equivalent Capacitance



$$Q = ?$$

$$\frac{1}{C_{EQ_1}} = \frac{1}{C_1} + \frac{1}{C_2}$$

Equivalent Capacitance



$$C_{EQ_2} = C_{EQ_1} + C_3$$

Equivalent Capacitance