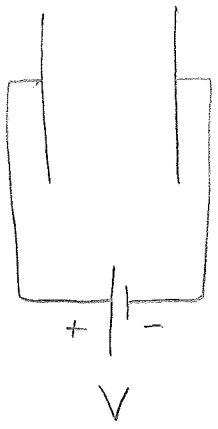
AP 2 Circuits

Capacitor



A parallel plate capacitor consists of 2 metal plates, each of area $10\,cm^2$ and separated by a 1.2 mm air gap. If the 2 plates hold $+3nC$ and $-3nC$ find (a.) the magnitude of the electric field between the plates and (b.) the energy stored in the capacitor.

The battery remains connected to the capacitor. After the capacitor becomes fully charged, the plate separation increases by a factor of 3. By what factor do the following change?

C

V

q

U_c

E

Now assume that the battery is removed when the capacitor is fully charged and then the plate separation increases by a factor of 3. By what factor does each of the following change?

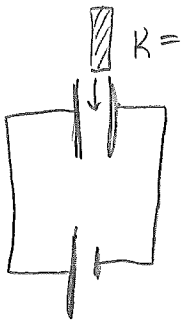
C

V

q

U_c

E



After the capacitor becomes fully charged, a dielectric is added with $k=5$ while the battery voltage stays connected.

By what factors do each of the following change?

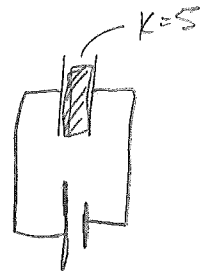
C

V

q

U_C

E



After the battery is disconnected, the dielectric is removed. By what factor does each of the following change?

C

V

q

U_C

E

Resistors in Series and Parallel Review

Parallel: $\frac{1}{R_{\parallel}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$

Series: $R_{eq} = R_1 + R_2 + \cdots$

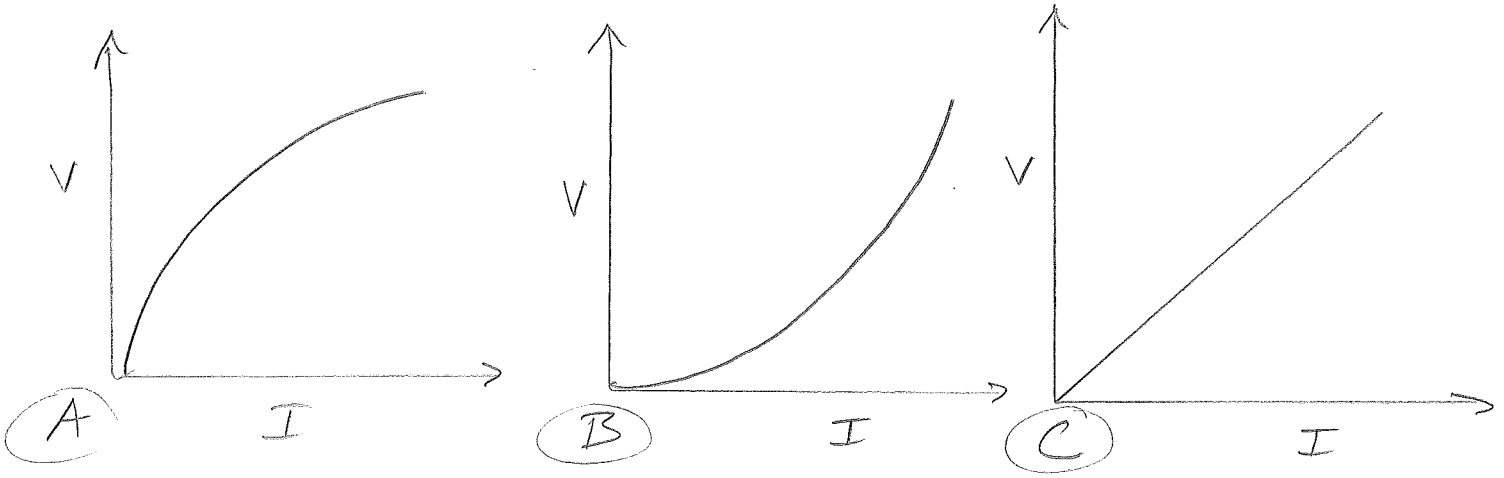
Resistivity Review: $\rho = \frac{RA}{L}$

Power: $P = IV = \frac{V^2}{R} = I^2 R$

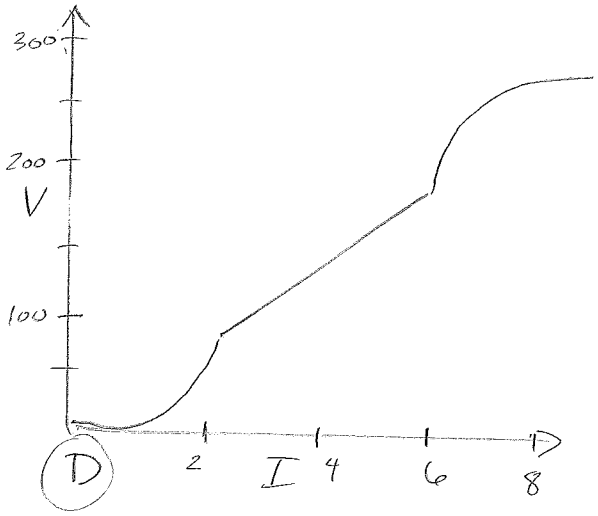
Ohmic Materials:

The many substances for which Ohm's Law ($V = IR$) holds are called ohmic. Substances that do not follow Ohm's Law are called non-ohmic.

Experiments were conducted on various materials using a variable power supply, a voltmeter, an ammeter, & a set of connecting wires. The following graphs were produced:



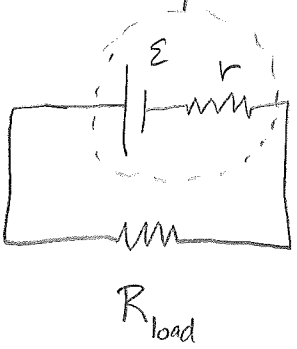
Which of the above represent ohmic materials?



During which current interval(s) is the material "D" ohmic?

The slope of voltage – current graph is _____.

Real Battery : electromotive force & internal resistance



electromotive force = $\mathcal{E}$ = emf

internal resistance = r

terminal voltage = $V_{terminal} = \mathcal{E} - V_r = \mathcal{E} - Ir$

load voltage = $V_{load} = IR_{load}$

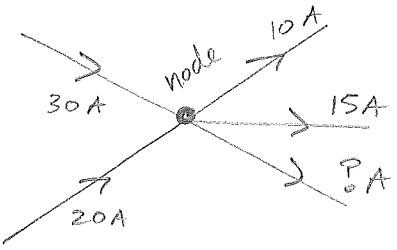
A 12V battery supplies 3A to a resistor. Its $V_{terminal}$ drops to 11V as it supplies the 3A.

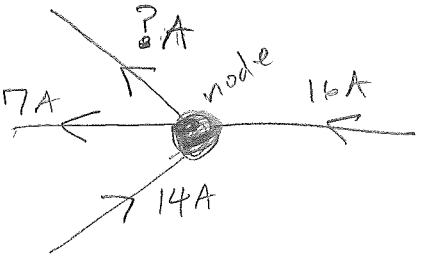
What is the internal resistance 'r'?

A 6-V battery with .2 Ω internal resistance is connected to an 8 Ω resistor. Find $V_{terminal}$ of the battery.

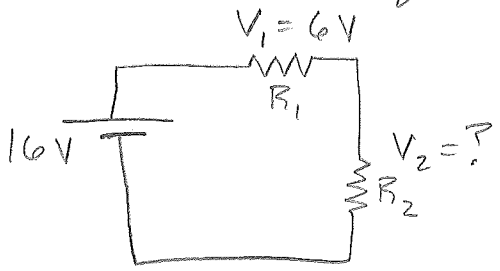
Kirchoffs' Laws:

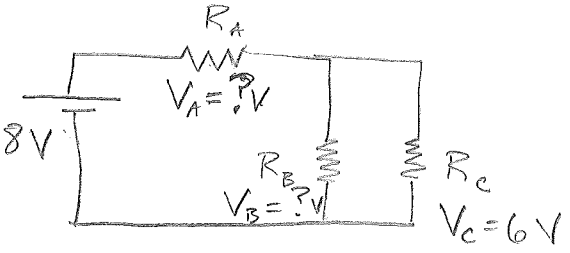
1. Current flowing into a node (or junction) must equal the current flowing out of it.



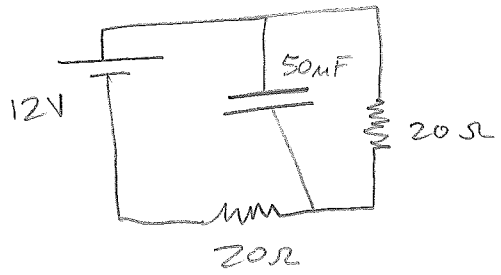


2. The sum of all voltages around any closed loop in a circuit must equal zero. The battery must be in the loop!



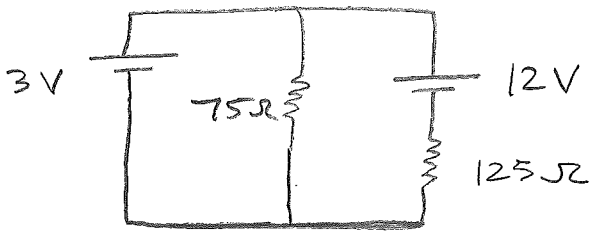


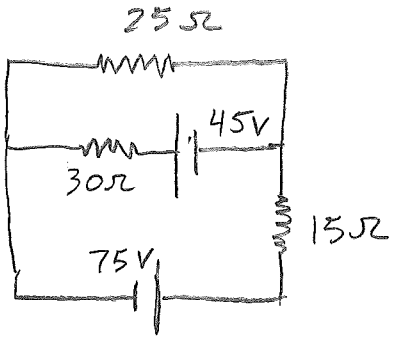
Example Problem:

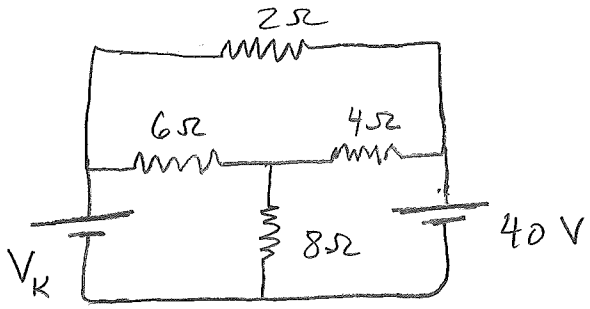


The circuit is in steady state. What is the potentral difference across the plates of the capacitor?

Kirchhoff's Rules Examples

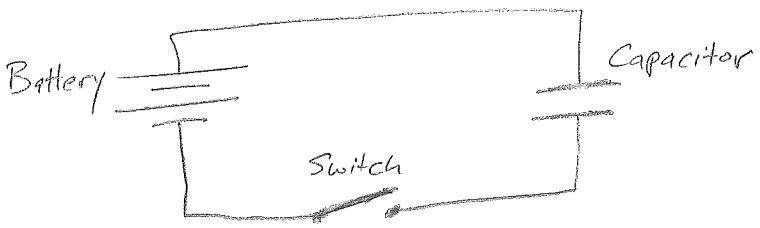




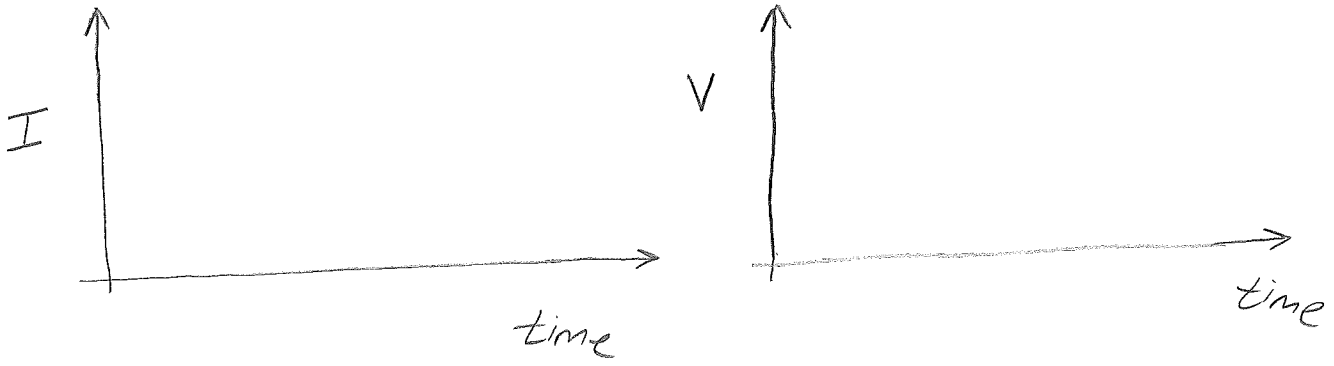


Capacitors in Circuits

The capacitor begins discharged.



Sketch the qualitative graphs once the switch is closed for the capacitor.



In a DC circuit a capacitor will eventually act as if it is an open switch. When no more charge flows we say the circuit is in steady state.

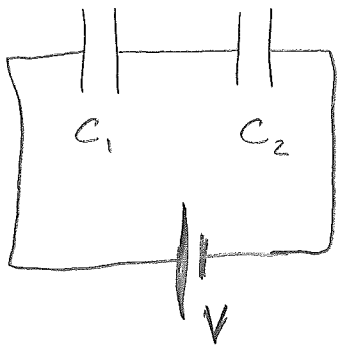
What is the charge stored on a 50 μF capacitor connected to a 9 V battery when steady state is reached?

$$Q = V \cdot C$$

What is the capacitance of a capacitor that stores 12 μC of charge when connected to a 6 V battery in steady state?

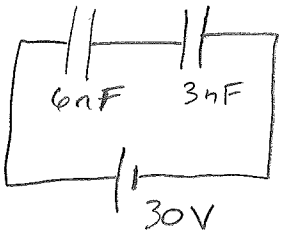
$$C = \frac{Q}{V}$$

In Series Capacitors:

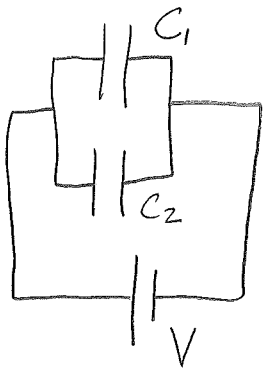


What is the equivalent capacitance?

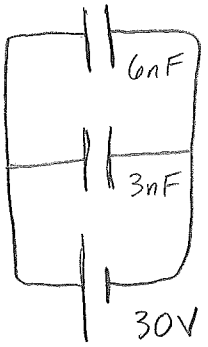
Find C_{eq} and V & q for each capacitor 6nF & 3nF:



Capacitors in parallel:

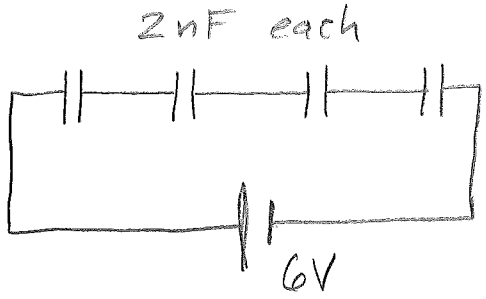


What is the equivalent capacitance?



a. Find C_{eq}.

b. Find V & q for each capacitor.

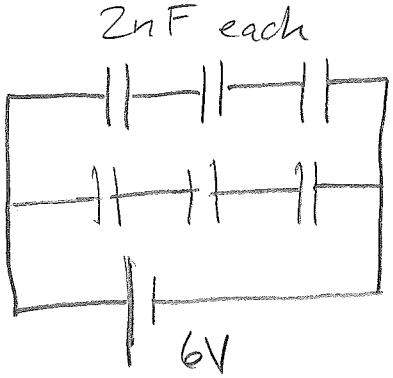


Find

a.) C_{eq}

b.) V & q for each

c.) $q_{battery}$



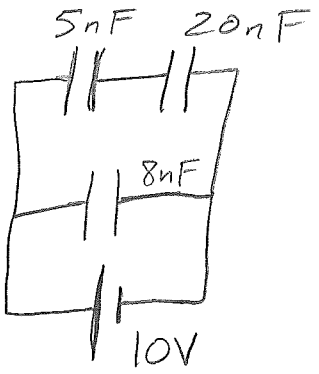
Find

a.) C_{eq}

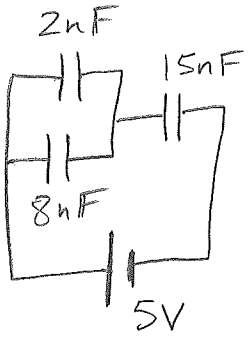
b.) V & q for each

c.) $q_{battery}$

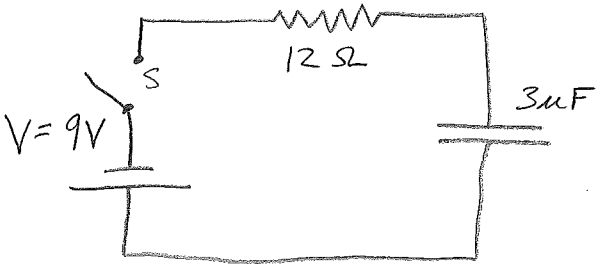
Find V & q for each capacitor:



Find V & q for each capacitor:



RC Circuits (Resistors & Capacitors)

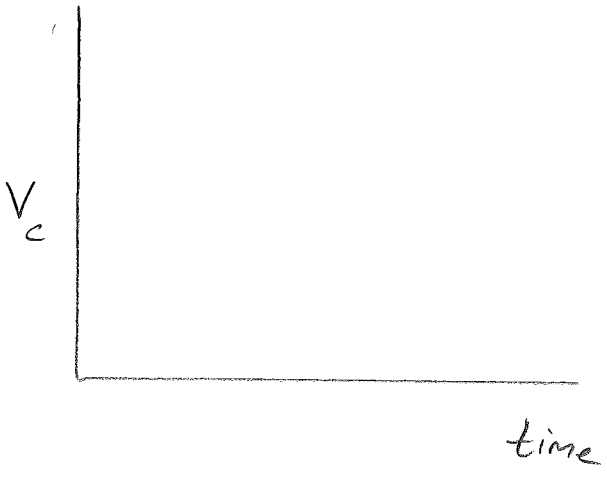


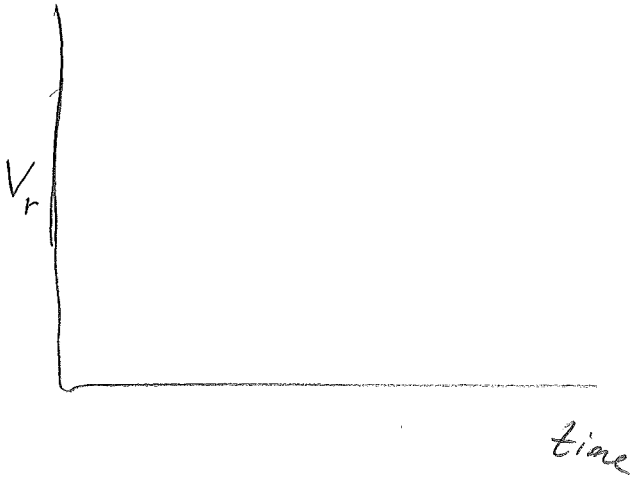
Immediately after the switch is closed what is the

1. Charge on capacitor
2. PD across capacitor
3. Current through the circuit
4. PD across resistor

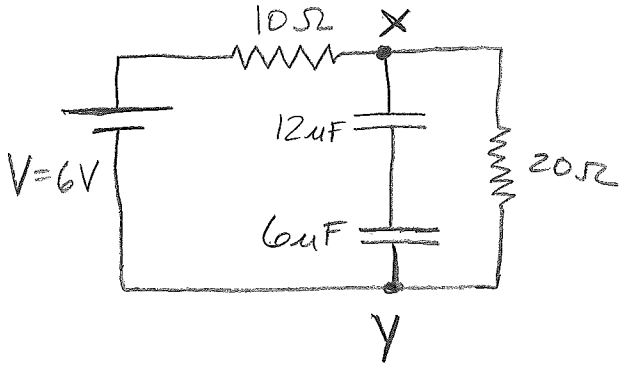
After a long time, answer questions 1-4 again:

Sketch the following qualitative graphs:

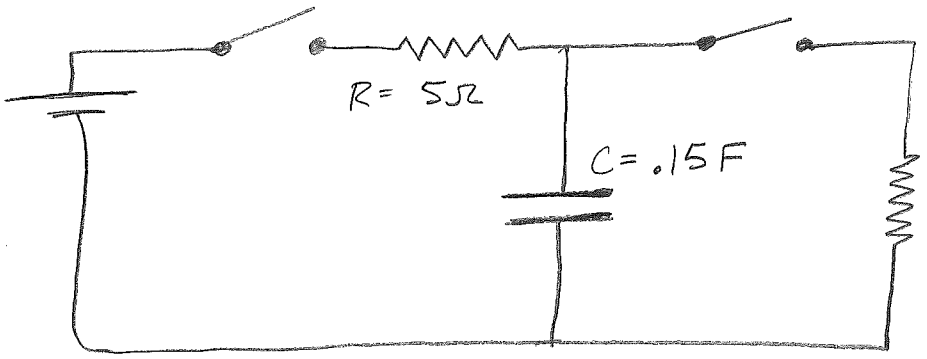




Assume the circuit has been closed and running for a long time:



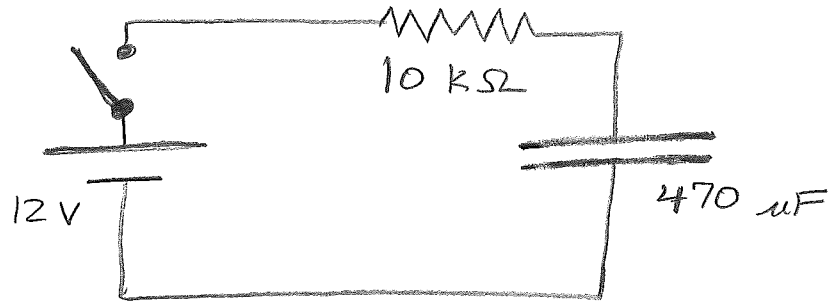
1. What is the total capacitance of the circuit?
2. What is the current through the 10Ω resistor?
3. What is the potential difference across points X and Y?
4. What is the charge stored on the 6μF capacitor?
5. What is the potential difference for each capacitor?


R = 5Ω
C = .15 F

Charging a Capacitor

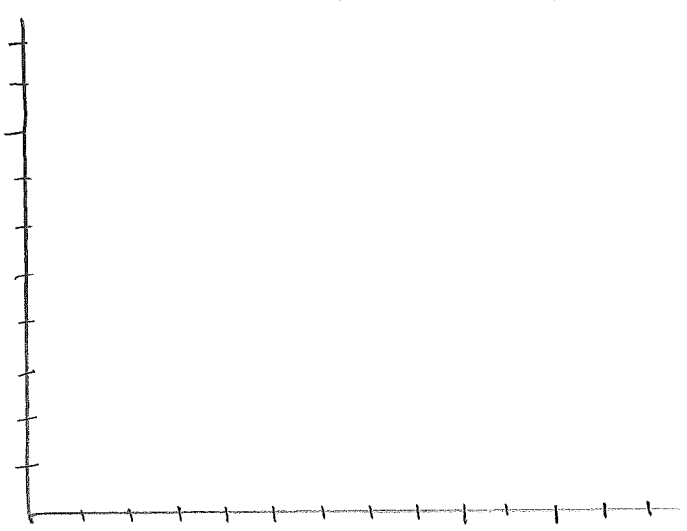
Time Constant

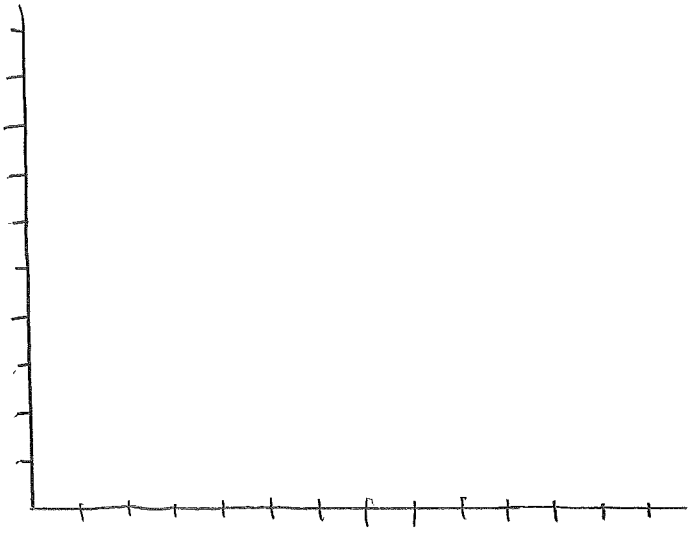
$\tau = RC$



$V(t) = V_B\left(1 - e^{-t/RC}\right)$

$I(t) = I_0\left(e^{-t/RC}\right)$

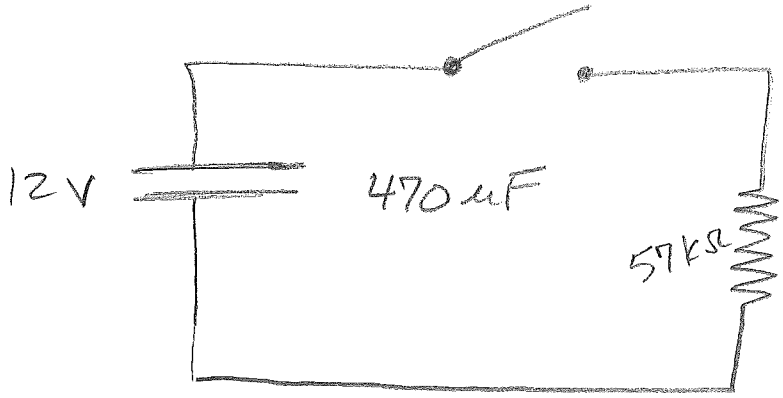




Charging a Capacitor

1. What value of voltage will be across the capacitor after 2 time constants?
2. What value will the voltage be across the capacitor after 6 seconds?
3. When will the capacitor be fully charged?
4. When will the current through the circuit be reduced by 25%?

Discharging a Capacitor

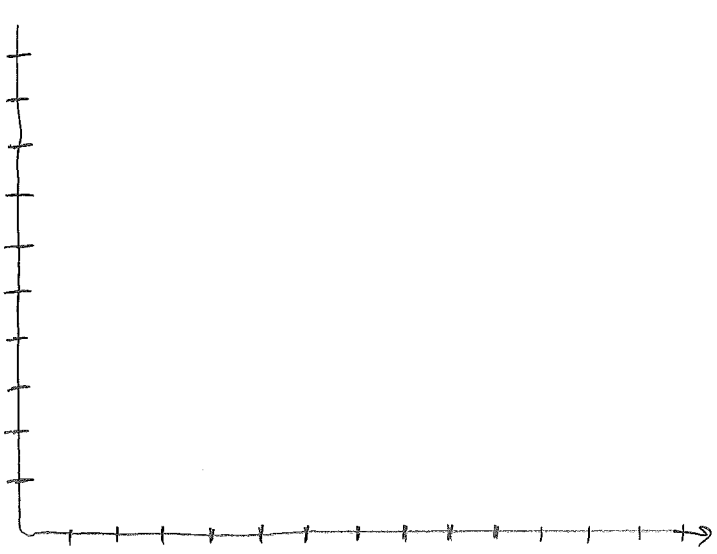


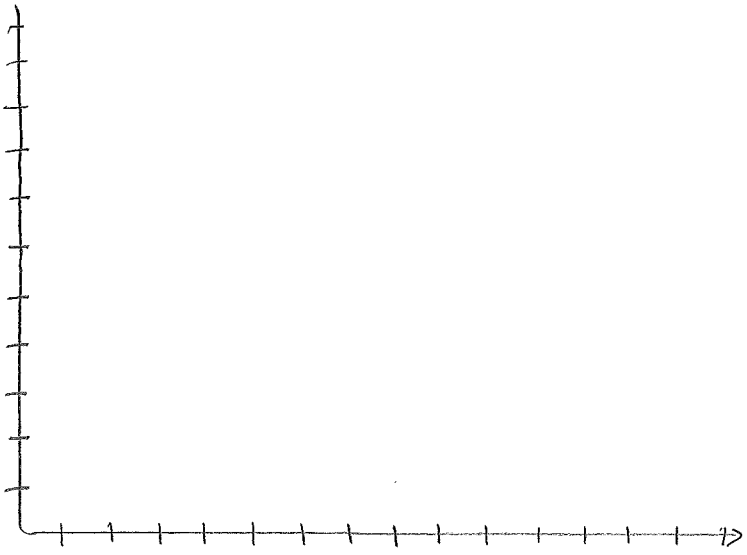
Time Constant

$\tau = R \cdot C$

$V(t) = V_0 (e^{-t/RC})$

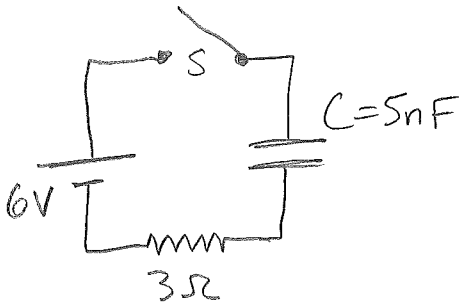
$I(t) = I_0 (e^{-t/RC})$





Discharging a Capacitor

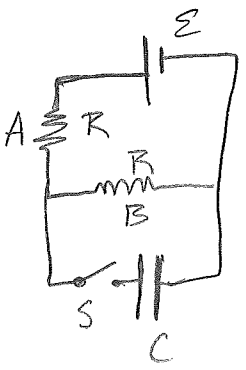
1. What will be the voltage across the capacitor after 1 time constant?
2. What will be the voltage across the capacitor after 20 seconds?
3. When will the capacitor be fully discharged?



C is initially uncharged.
Then S is closed.

Find a.) $I_{3\Omega}$ the moment after S is closed

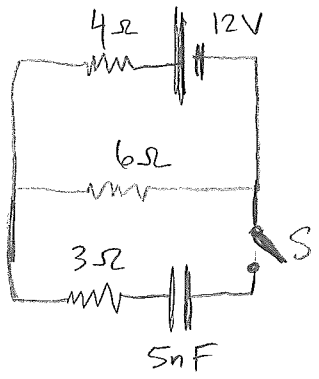
b.) $I_{3\Omega}$ and q_{5nF} a long time later.



C: initially uncharged. S is then closed.

a.) Find I_A & I_B the moment after S is closed.

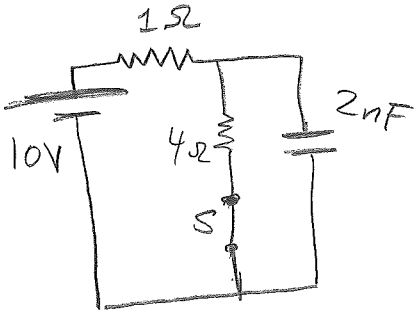
b.) Find I_A, I_B & q a long time later.



Capacitor is initially uncharged.
S is then closed.

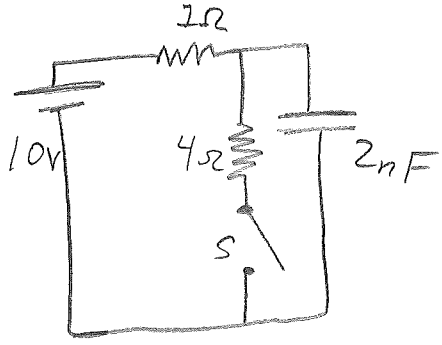
a.) Find $I_{4\Omega}$, $I_{6\Omega}$, $I_{3\Omega}$ the moment after S is closed.

b.) Find $I_{4\Omega}$, $I_{6\Omega}$, $I_{3\Omega}$ & q a long time later.

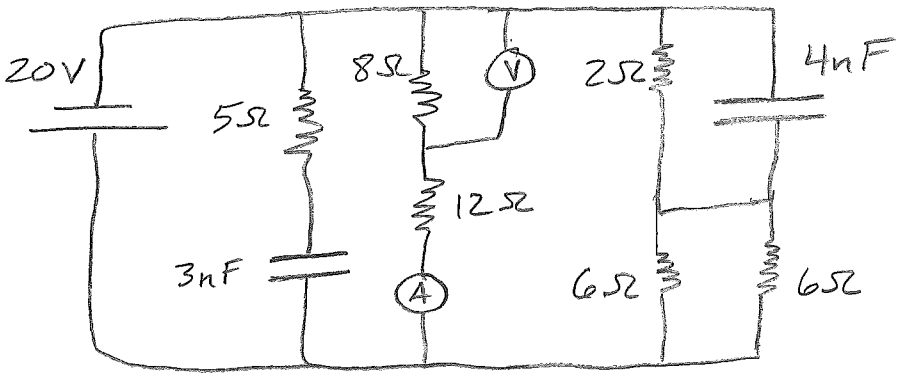


S has been closed for a long time.
$q = ?$

Then open S immediately and find I in each resistor.



A long time later find $I_{1\Omega}$ & q.



Find readings:

a.) (A)

b.) (V)

c.) q_{3nF}

d.) q_{4nF}