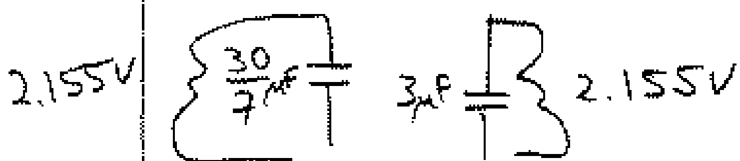
now, we examine the $\frac{30}{7}\mu F$ combo in parallel with the $3\mu F$ combo. The voltage across each is 2.155V.



$Q = CV$

$Q_{3\mu F} = (3\mu F)(2.155V)$

$= 6.465\mu C$

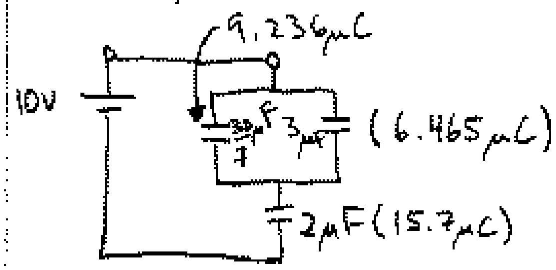
$Q_{\frac{30}{7}\mu F} = \left(\frac{30}{7}\mu F\right)(2.155V)$

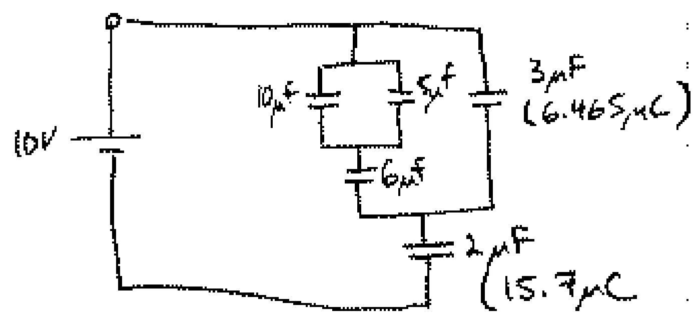
$= 9.236\mu C$

check $Q_{tot} = 6.465\mu C + 9.236\mu C = 15.7\mu C$

great!

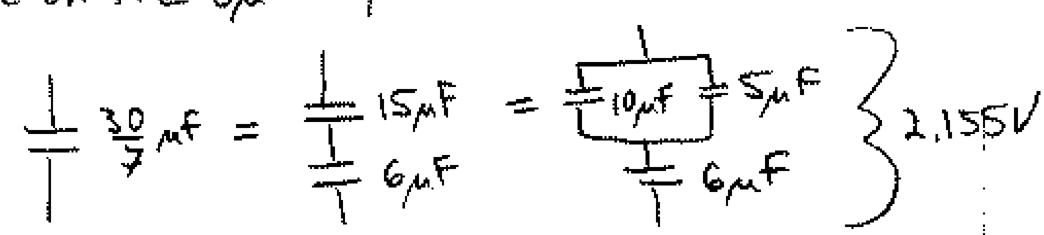
So, here's what we have so far & where we want to





notice that Q on the $\frac{30}{7}\mu F$ combo is the same as the charge on the $6\mu F$ cap

Recall



so q on $6\mu F \Rightarrow 9.236\mu C$

And we can use the same trick as before

$2.155V$ = voltage across $6\mu F$ + voltage across $15\mu F$ combo

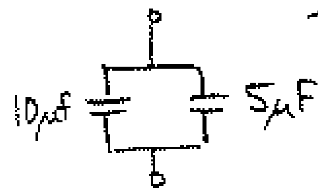
$$= \frac{9.236\mu C}{6\mu F} + \frac{9.236\mu C}{15\mu F}$$

$$= 1.54\,V + 0.6157\,V = 2.156\,V$$

close!

So, the voltage across the $15\mu F$ combo is

$0.6157V$

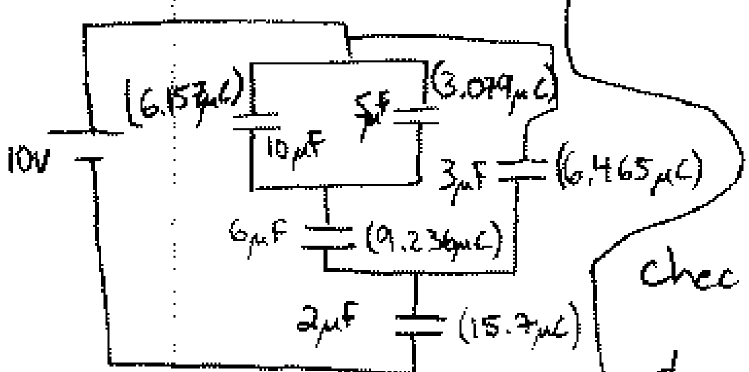


$\}\ 0.6157V$

so $Q_{5\mu F} = 5\mu F(.6157\,V)$
$= 3.079\,\mu C$

$Q_{10\mu F} = 10\mu F(0.6157\,V)$
$= 6.157\mu C$

Final



check $Q_{5\mu F} + Q_{10\mu F} = 9.236\mu C$

& $3.079\mu C + 6.157\mu C = 9.236\mu C$

cool!

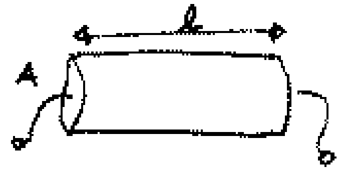
now, as a check, the potential difference across the $10\mu F$ + $6\mu F$ + $3\mu F$ = $10V$

$0.6157V + 1.54V + 7.85V = 10.005V$ good

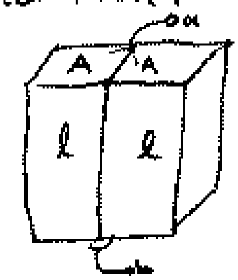
We've been talking about resistance.

Recall that

$$R_{ab} = \rho \frac{l}{A}$$



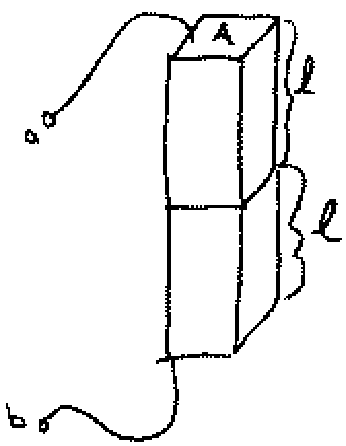
Now, like capacitors, we will have to deal with combinations of Resistors. Again, consider 2 Identical resistors



side by side we get 2x Area

$$\frac{1}{R_{new}} = \frac{1}{l\rho}(A+A) = \frac{2A}{l\rho}$$

$$R_{new\,parallel} = \frac{\rho l}{2A} \qquad \frac{1}{2} R \text{ of } 1$$



like

$$R_{new\,series} = \frac{\rho}{A}(l+l) = 2R_{one}$$

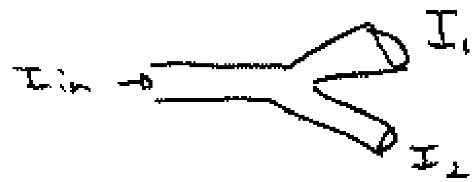
Backwards from capacitors!

		Resistor	Capacitor
	eqn	$\frac{\rho l}{A}$	$\frac{\varepsilon_0 A}{d}$
add areas	parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$	$C = C_1 + C_2 + C_3$
add gaps	series	$R = R_1 + R_2 + R_3$	$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

So how do we motivate this. Very similar to capacitors. We'll use voltage and charge. This time though charge conservation becomes current conservation.

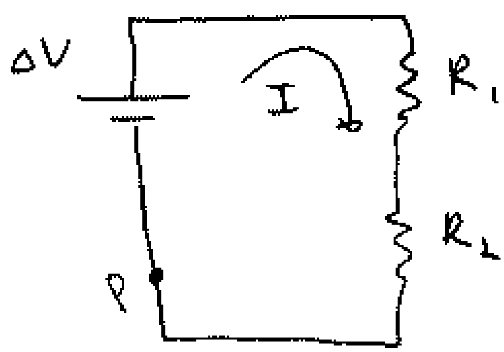
If we have current flow in a conductor

$I_{in} = I_{out}$ & the current is constant (like we evaluate charge at equilibrium)



$$I_{in} = I_1 + I_2$$

so, in the series combination



I through R_1 is the same as I through R_2

now, if I pick a point on the circuit and follow it in the direction I drew the current. I know: {ΔV is Potential across R_1 & R_2}

Charges get a boost in potential as they pass through the battery

Recall, those resistors get hot as current passes through.

So, if we call the point where we started 0V

get $+\Delta V_{batt}$ through the batter

loose ΔV_1 as we pass through R1
ΔV_2 as we pass through R2

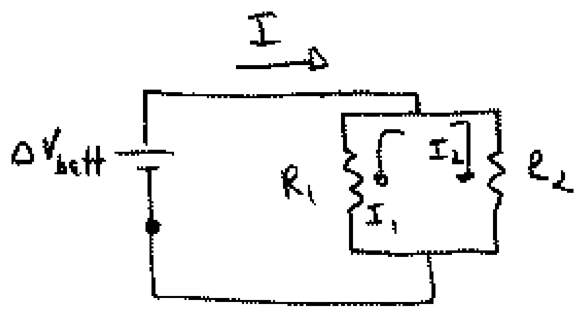
$$0 = \Delta V_{batt} - \Delta V_1 - \Delta V_2$$

$$= \Delta V_{batt} - I R_1 - I R_2$$ Since same I passes through everything

$$I R_1 + I R_2 = \Delta V_{batt}$$

$$I \underbrace{(R_1 + R_2)}_{R_{equivalent}} = \Delta V_{batt}$$

Lets do the same with parallel



$$\Delta V_{batt} - I_1 R_1 = 0 \qquad \frac{\Delta V_{batt}}{R_1} = I_1$$

$$\Delta V_{batt} - I_2 R_2 = 0 \qquad \frac{\Delta V_{batt}}{R_2} = I_2$$

$$I_1 R_1 = I_2 R_2$$

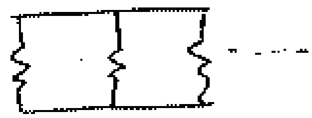
$$I = I_1 + I_2$$

$$= \frac{\Delta V_{batt}}{R_1} + \frac{\Delta V_{batt}}{R_2}$$

$$= \Delta V_{batt} \left(\frac{1}{R_1} + \frac{1}{R_2} \right)$$

$$= \Delta V_{batt} \left(\frac{1}{R_{equiv}} \right)$$

So, how do we deal with a complicated banch of Resistors? Look at a small piece & as Is current the same through these?! Is voltage across the same



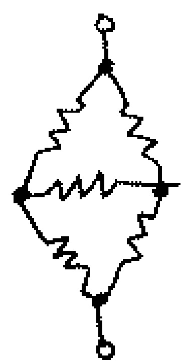
voltage across is same

or

Current through is same

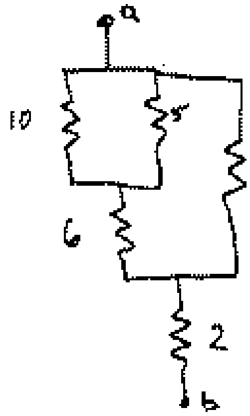
you can replace these with equivatent resistances

if you see



for instance, you need a higher technique

lets go through an example of equivalent Resistance that Can be done with our replacements



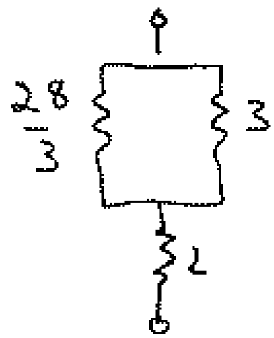
10 & 5 in parallel

$$\frac{1}{R} = \frac{1}{10} + \frac{1}{5} = \frac{3}{10}$$

$$R = {}^{10}/_{3} \quad (3.33\,\Omega)$$

$\frac{10}{3}$ & 6 in series

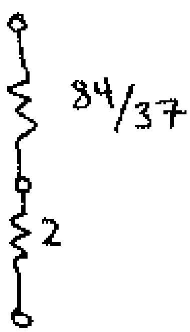
$$R = \frac{10}{3} + 6 = \frac{28}{3} \quad (9.33\,\Omega)$$



$\frac{28}{3}$ & 3 in parallel

$$\frac{1}{R} = \frac{1}{3} + \frac{3}{28} = \frac{28}{84} + \frac{9}{84} = \frac{37}{84}$$

$$R = \frac{84}{37} \quad (2.27\,\Omega)$$



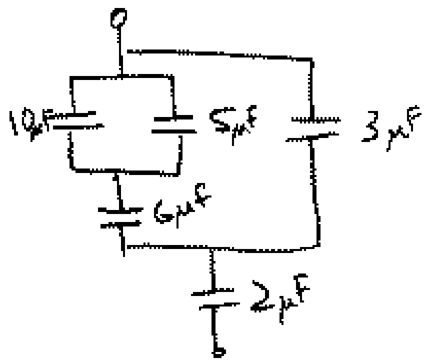
$$R_{series} = 2 + \frac{84}{37} = \frac{74}{37} + \frac{84}{37}$$

$$= \frac{158}{37}$$

$$\sim 4.27\,\Omega$$

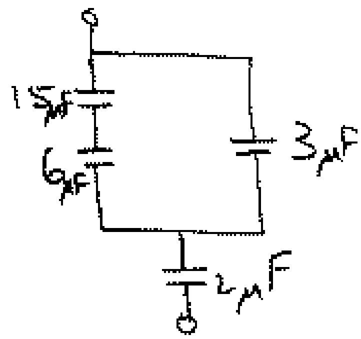
for capacitors you can ask is q same on each
V across same

lets do the same one
with caps! (all in μF



10 & 5 in Parallel

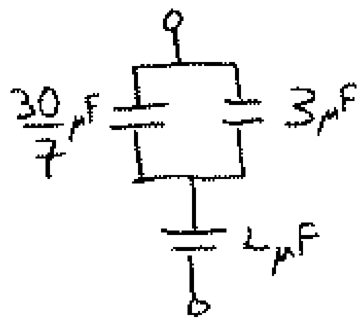
$$C = 10\mu F + 5\mu F = 15\mu F$$



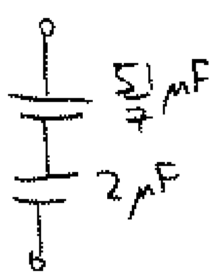
15 & 6 in series

$$\frac{1}{C} = \frac{1}{15\mu F} + \frac{1}{6\mu F} = \frac{2}{30} + \frac{5}{30} = \frac{7}{30}$$

$\frac{30}{7}$ + 3 in parallel



$$C = \frac{30}{7} + 3 = \frac{51}{7}\mu F$$



$\frac{51}{7}$ & 2 in series

$$\frac{1}{C} = \frac{7}{51\mu F} + \frac{1}{2\mu F} = \frac{14}{102} + \frac{51}{102}$$
$$= \frac{65}{102\mu F}$$

$$C = \frac{102}{65}\mu F$$ different

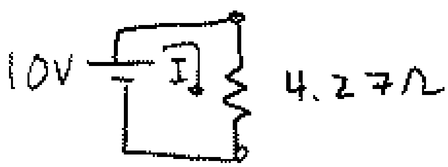
$= 1.57\mu F$

Smallest resistor dominates in parallel
Smallest capacitor dominates in series

Now, lets put a voltage across our combination and try to determine the current in each element

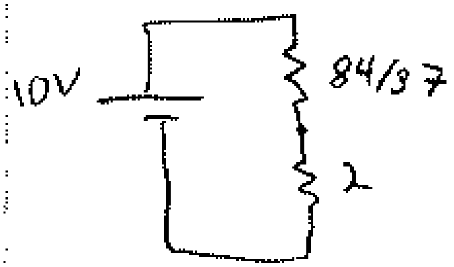
As in your homework, we try to work backwards

our equivalent resistor looks like

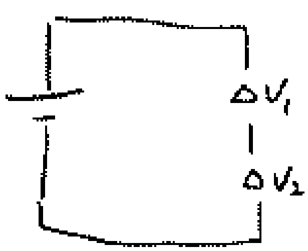


$I = \frac{\Delta V}{R} = \frac{10V}{4.27\Omega} = 2.34A$

this means we have 2.34A flowing through

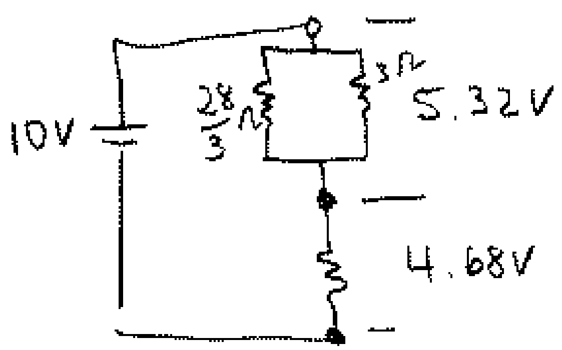


too 2.34A flowing through 2Ω produced a 4.68V potential drop



from previous means $\Delta V_1 = 10V - 4.68V$
$= 5.32V$

so we really simplify the problem



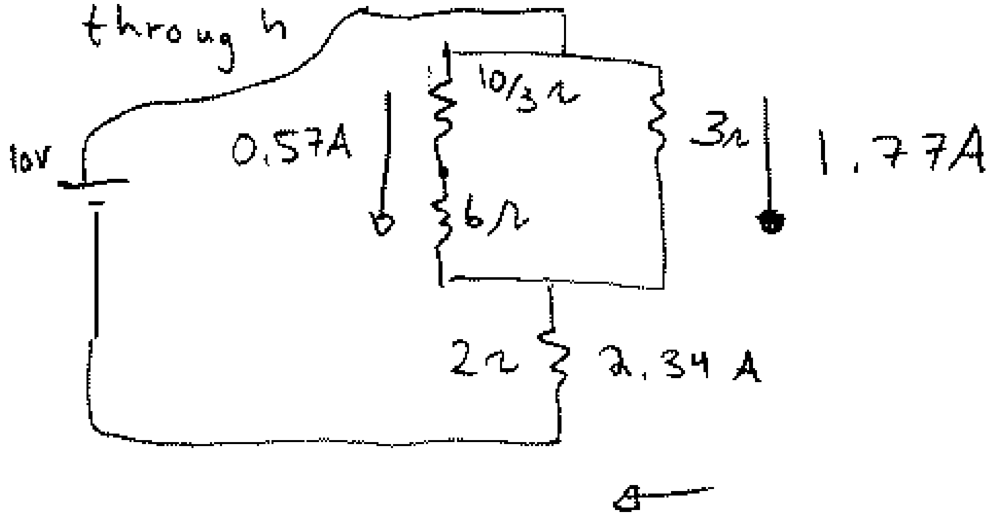
can easily figure out current in each

in 3Ω, $I = \frac{5.32}{3} = 1.77A$

9.333Ω, $I = \frac{5.32}{9.333} = .57A$

$I_{tot} = 1.77 + .57 = 2.34A$, cool!

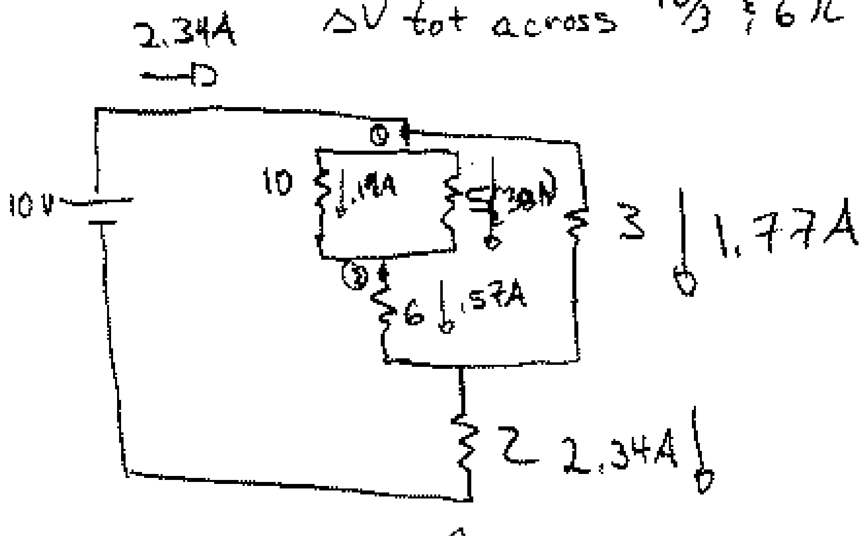
so, we now know that 0.57A flows through



so the voltage drop across the $10/3\ \Omega$ is $\frac{10}{3} \cdot .57 = 1.9V$

check Voltage across 6Ω is $6\Omega(.57A)$
$= 3.42V$

ΔV tot across $10/3$ & $6\Omega = 5.32V$ good!



ΔV between ① and ② is

1.9V

$I_{10} = \frac{1.9V}{10\Omega} = .19A$

$I_5 = \frac{1.9V}{5\Omega} = .38A$

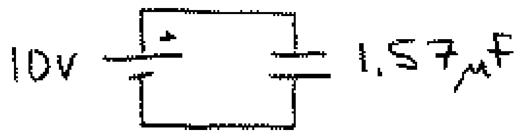
hottest!
resistor

$I_{tot} = 0.19A + 0.38A + 1.77A$
$= 2.34A$ all checks

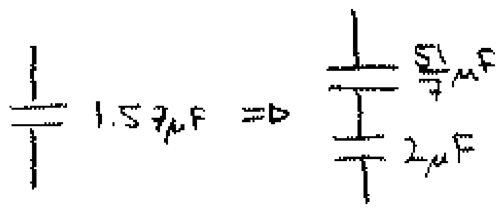
How about the capacitor system if we put a voltage on it

- look for series ↔ same charge
- look for parallel ↔ same voltage

Our equivalent circuit



$$Q = CV$$
$$= 1.57\mu F(10V) = 15.7\mu C$$



charge is same as Q above so q on 2μF is 15.7μC

We should be able to check this, add up the potential differences on each, we get 10V

$$10V \overset{\text{should}}{=} \frac{15.7\mu C}{(51/7\,\mu F)} + \frac{15.7\mu C}{2\mu F}$$

$$= 2.155V + 7.85V = 10.0005V$$

pretty close!

So, we know the potential difference across the $\frac{51}{7}$ μf combination is 2.155V.