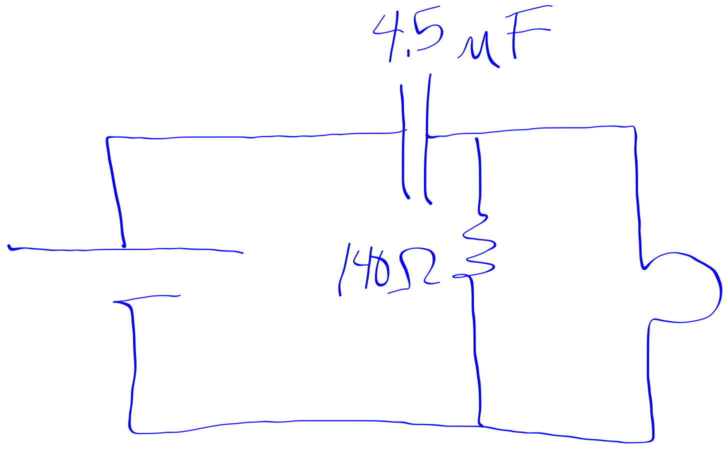
20. A 4.5 μF capacitor is wired in series with a light bulb of negligible resistance. A 140 Ohm resistor is wired in parallel with the lightbulb. If this circuit is powered by an unstable AC power source (one that produces uneven voltage that is a combination of many different frequencies), which frequencies will be filtered out so they don't affect the light bulb? [All frequencies ~~above~~ < about 253 Hz]



RC circuit:

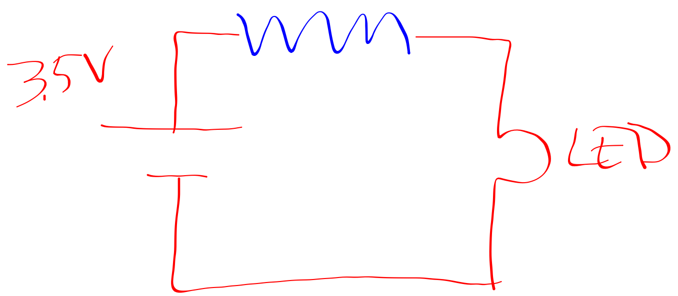
High-pass filter

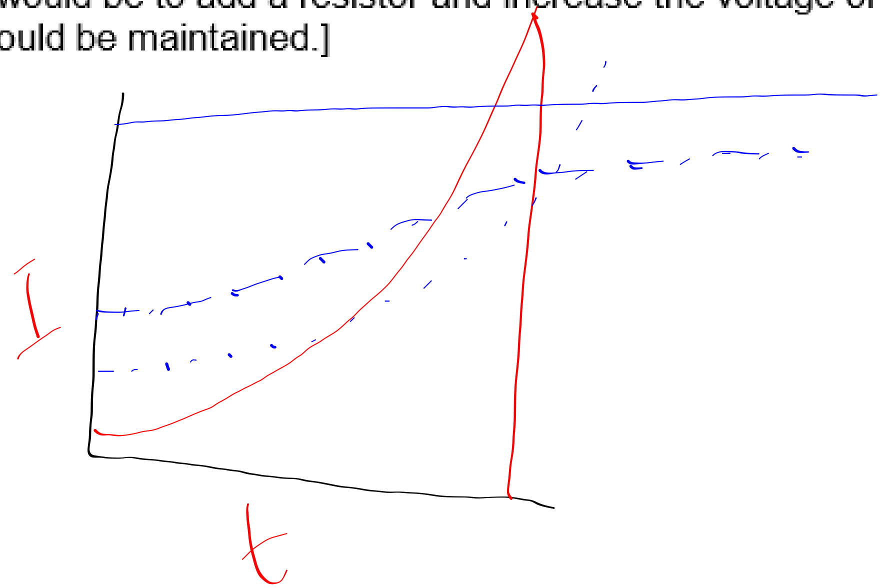
cutoff frequency

$$\frac{1}{2\pi RC} = 253\ \text{Hz}$$

Freq. above 253 Hz will flow to light bulb

21. An LED is designed to produce its maximum brightness at 20 mA, when it will have a resistance of about 175 Ohms. Its lifespan will be greatly reduced if it is run at a current more than 20 mA for an extended time. It is hooked to a DC power source of 3.5 V. When the power is turned on, the LED briefly glows, then burns out. What happened and why? What could be changed to prevent this problem, and how might that affect the brightness of the LED? [The LED has variable resistance. While it will have a resistance of 175 Ohms at 20 mA, it won't stay at that resistance. As the resistance drops, the current increases until the LED is broken. A resistor could be put in series with the LED – but that would make it impossible to achieve a current of exactly 20 mA through the LED, which would mean the LED will either be receiving too much current (thus shortening its lifespan) or not enough current (in which case it won't be at its maximum brightness). Another option would be to add a resistor and increase the voltage of the power supply, in which case the ideal current could be maintained.]

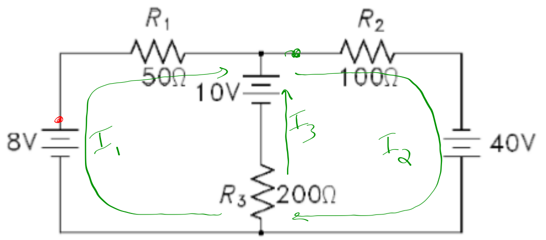




$$V = IR$$

$$3.5 = 20\,mA\,(175\,\Omega)$$

22. Find the current through R_1, R_2, R_3 in the circuit below. [R_1 = 268.6 mA to the left, R_2 = 345.8 mA to the left, R_3 = 77.2 mA down]



Junction Rule: $I_1 + I_3 = I_2$ / $I_3 = I_2 - I_1$

Loop Rule: $8 - 50I_1 - 100I_2 + 40 = 0$

$-50I_1 - 100I_2 + 48 = 0$

$-100I_2 + 48 - 200I_3 + 10 = 0$

$-100I_2 - 200I_3 + 50 = 0$

$\boxed{I_2 = \frac{-50I_1 + 48}{100}}$

$-100I_2 - 200(I_2 - I_1) + 50 = 0$

$-100I_2 - 200I_2 + 200I_1 + 50 = 0$

$-300I_2 + 200I_1 + 50 = 0$

$\boxed{I_2 = \frac{200I_1 + 50}{300}}$

$3\frac{(-50I_1 + 48)}{\cancel{100}} = \frac{200I_1 + 50}{\cancel{300}}$

$-150I_1 + 144 = 200I_1 + 50$

$350I_1 = 94$

$\boxed{I_1 = 0.269\ A}$

$= \frac{200(0.269) + 50}{300}$

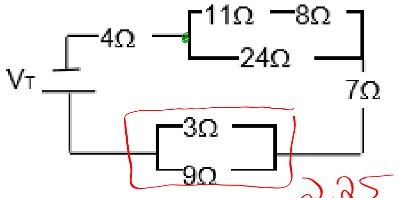
$\boxed{I_2 = 0.346\ A}$

$\boxed{I_3 = 0.077\ A}$

3. The potential across the 8Ω resistor is 12 V. Find the following: I_8, I_{11}, V_{24}, I_{24}, I_4, V_4, V_7, I_3, V_T. Here the subscript denotes that value associated with the specified resistor. [1.5A, 1.5A, 28.5V, 1.19A, 2.69A, 10.8V, 18.8V, 2.02A, 64.1V]

3.

$\Delta V = 16.5V$ $\Delta V = 12V$



2.25Ω

$$V_8 = I_8 R_8$$
$$12 = I_8 (8)$$
$$I_8 = 1.5 A$$
$$I_{11} = 1.5 A$$
$$V_{11} = I_{11} R_{11} = (1.5)(11) = 16.5V$$

$$V_{24} = I_{24} R_{24}$$
$$28.5 = I_{24} (24)$$
$$I_{24} = 1.19 A$$

$$I_4 = 2.69A \cdot (4) = V_4 = 10.8V$$
$$I_7 = 2.69A\,(7) = 18.83V$$

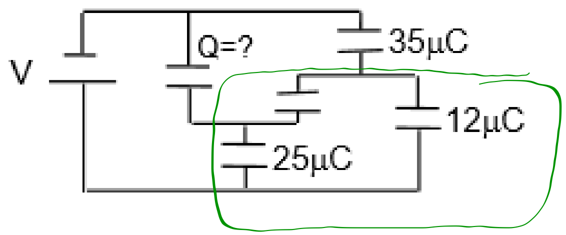
$$I_{3+9} = 2.69A \cdot 2.25 = V_{3+9} = 6.05V$$

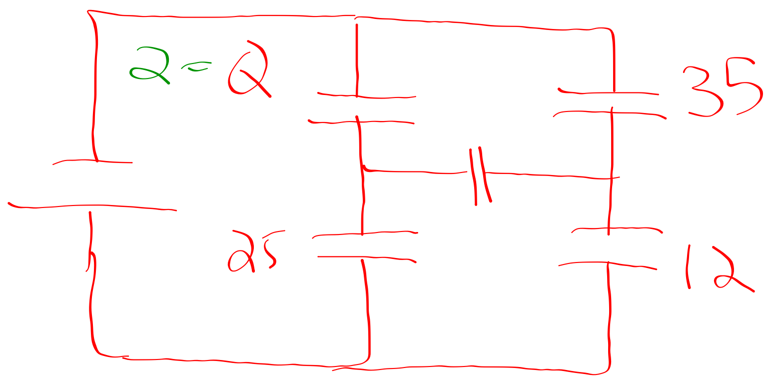
$$V_3 = I_3 R_3$$
$$6.05 = I_3 (3)$$
$$I_3 = 2A$$

$V_T =$ all voltage drops added... $= 64.1 V$

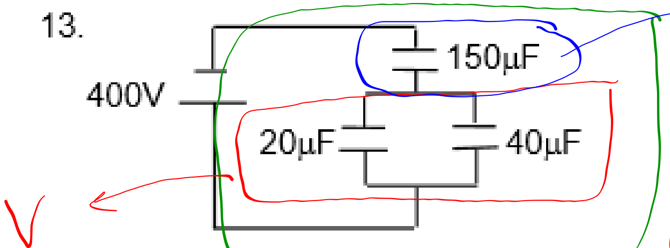
12. Given the charges stored on the capacitors shown, find the unknown charge. [2µC]

12.





13. For the given diagram, determine the charge stored on the 150-µF and the 40-µF capacitors. [.0171C; .0114C]



$Q = CV$; $V = Q/C = \frac{0.0184}{150\mu F}$

$V = 123\,V$

$C_{EQ} = 60\,\mu F$

$Q = 0.0184\,C$

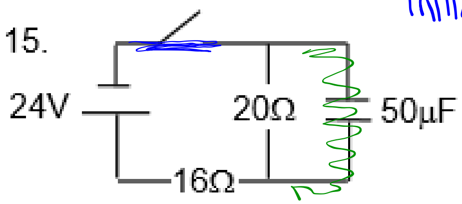
$V = 277\,V$

$C_{EQ} = \frac{1}{\frac{1}{150\mu F} + \frac{1}{60\mu F}} = 43\,\mu F$

$Q_T = C_T V_T = (43\,\mu F)(400V) = \boxed{0.0184\,C}$

$Q_{40} = C_{40} V_{40} = 40\,\mu F \cdot 277V = \boxed{0.011\,C}$

15. Find the currents through each resistor the instant the switch is closed, and after the circuit has reached an equilibrium state (e.g. the capacitor has become fully charged). [Initially: I_{20} = 0.0A, I_{16} = 1.5A; final equilibrium I_{20} = I_{16} = .667A]



initially... $R_{TOT} = 16\Omega$

$V = IR$

$24 = I_{16} \cdot 16$

$I_{16} = 1.5A$

$I_{20} = 0$

after... $R_{TOT} = 36\Omega$

$V = IR$

$24 = I(36)$

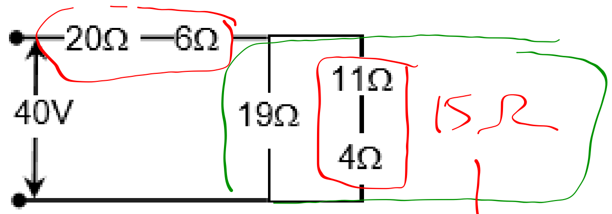
$0.67A = I = I_{16} = I_{20}$

6. What is the current in the 4Ω resistor? [.65 A]

$V = 30.23$

$I = 1.16$

6.



8.4Ω / 9.77 V

$R_{TOT} = 34.4$

$I_{TOT} = 1.16A$

$V = 9.77\ V$

$R = 15\Omega$

$I = 0.651\ A$