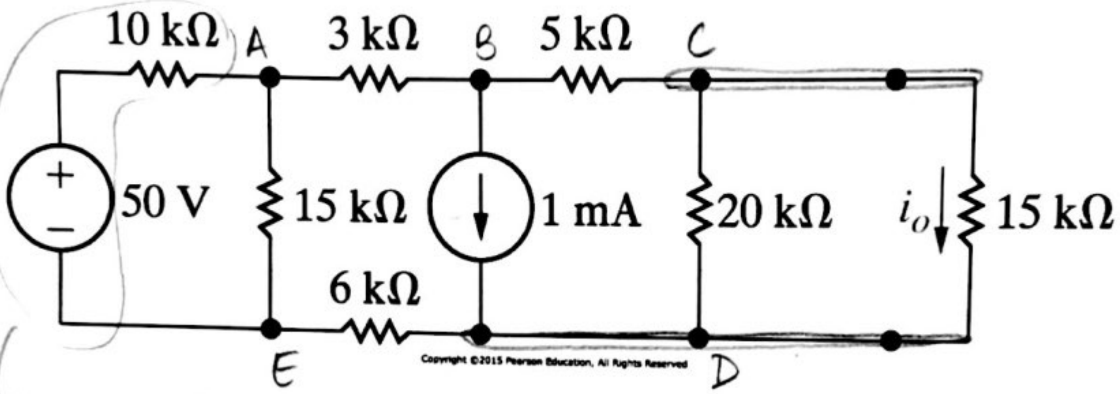
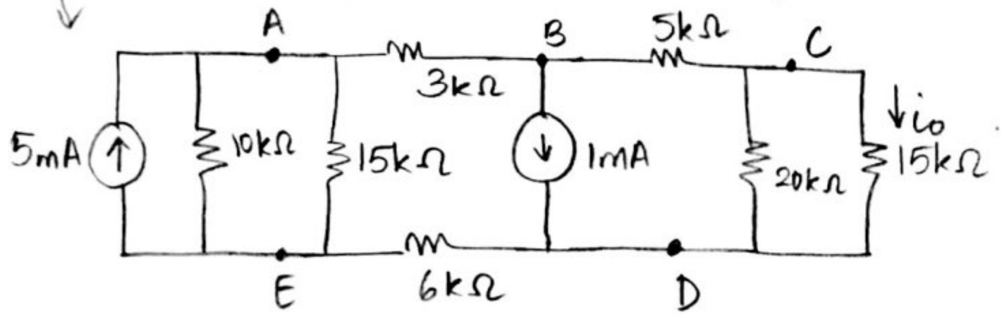
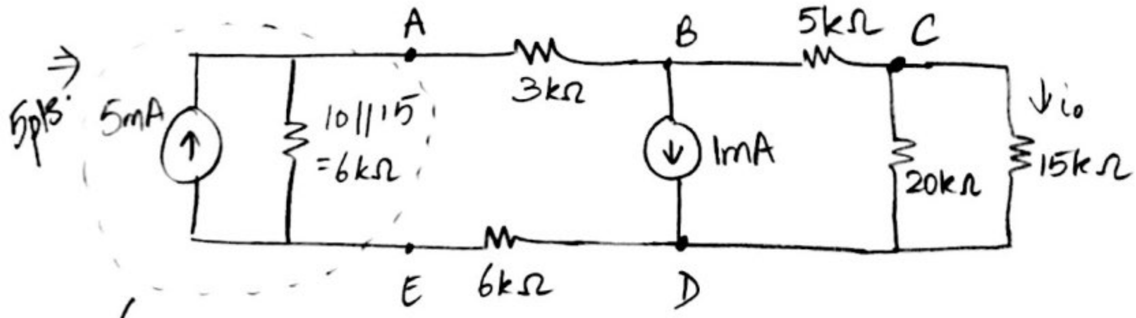
-4 for every conversion w/o a resistor.

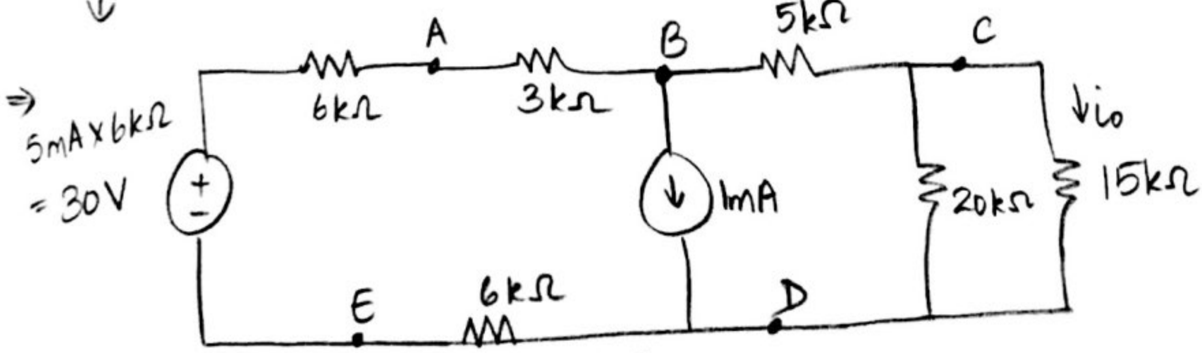
1. Using a series of souce transformations, simplify the circuit and determine the current i_0. ***Please make sure to draw out each subsequent circuit.*** *[25 points]*

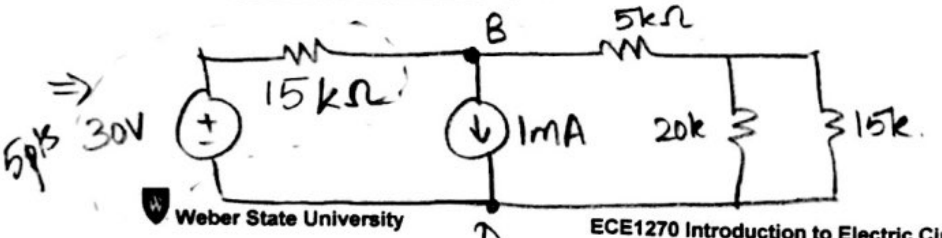




$i_0 =$ 0.3mA

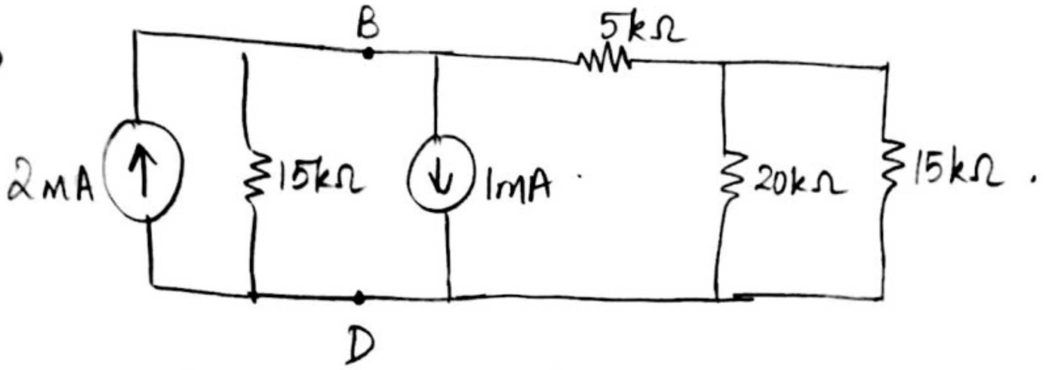




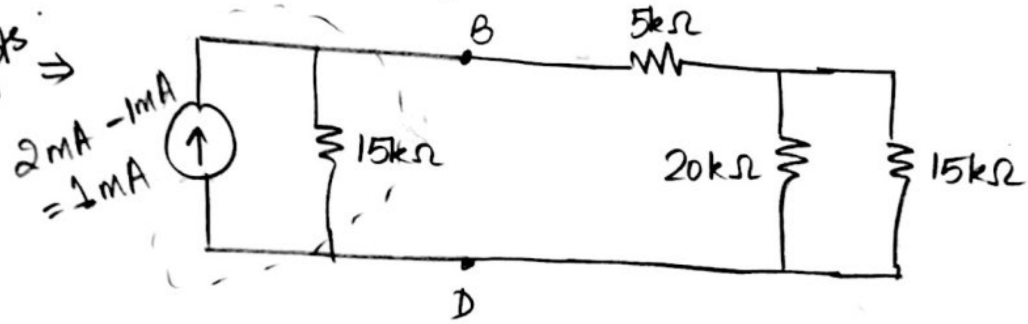


Page intentionally left blank. You may use this page for your work.

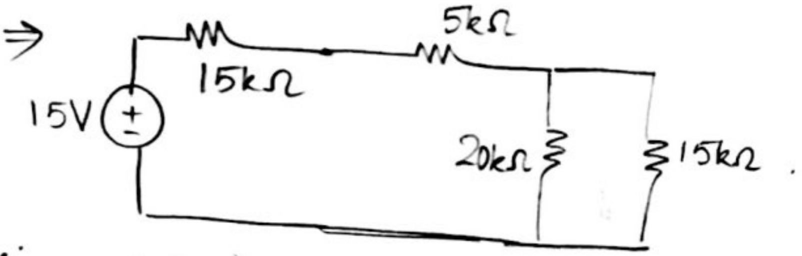
⇒



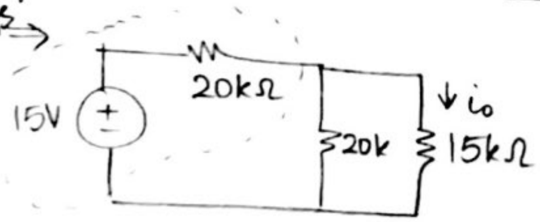
5pts ⇒



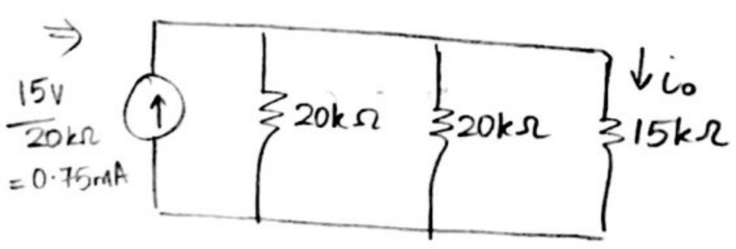
⇒



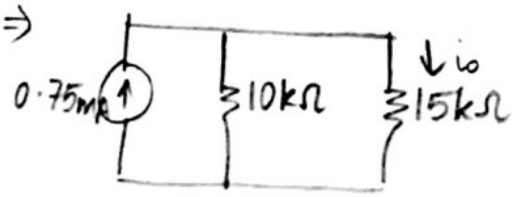
5pts ⇒



⇒



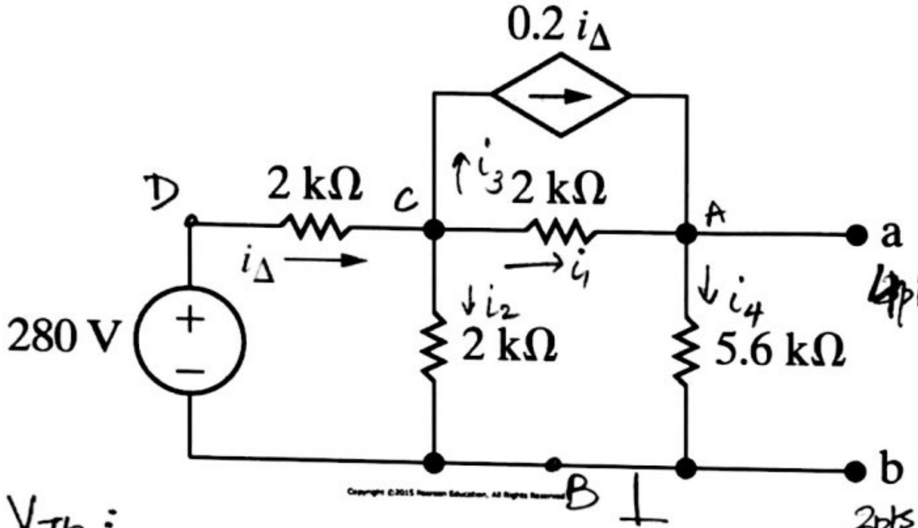
⇒



$$\Rightarrow \quad i_o = 0.75\text{mA}\left(\frac{6\text{k}\Omega}{15\text{k}\Omega}\right) \quad \text{5pts}$$

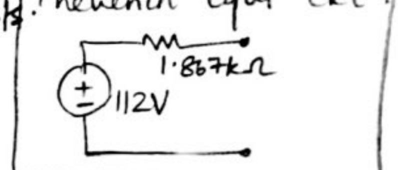
$$= \underline{\underline{0.3\text{mA}}}$$

2. A) **Draw** the Thevenin Equivalent with respect to terminals a,b for the circuit shown.
B) **Draw** the Norton Equivalent with respect to terminals a,b for the circuit shown.
C) Find the maximum power delivered by the circuit.
Please show all your intermediate circuits and separate your work into sections.
[25 points]

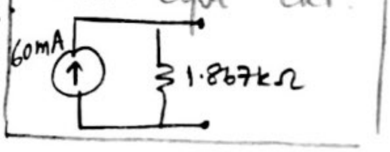


Vth = ________
Rth= ________
I_N = ________
R_N = ________
Pmax = 1.68 W

4pts. Thevenin Equt Ckt.



2pts Norton Equt ckt:



Finding V_{Th}:

$V_{Th} = V_{OC} = V_A$.

3pts. Given: $i_\Delta = \dfrac{V_D - V_C}{2k}$ & $V_D = 280V$

KCL @ C $\rightarrow$ $-i_\Delta + i_1 + i_2 + i_3 = 0$

3pts.

$$-\left(\frac{280 - V_C}{2k}\right) + \frac{V_C - V_A}{2k} + \frac{V_C}{2k} + 0.2 i_\Delta = 0$$

$$\Rightarrow V_C - 280 + V_C - V_A + V_C + 0.2(280 - V_C) = 0.$$

$$\Rightarrow -V_A + 2.8V_C = 224. \quad — \quad (1).$$

KCL @ A $\rightarrow$ $-0.2i_\Delta - i_1 + i_4 = 0$

3pts.

$$\Rightarrow -0.2\left(\frac{280 - V_C}{2k\Omega}\right) - \left(\frac{V_C - V_A}{2k}\right) + \frac{V_A}{5.6k} = 0$$

Page intentionally left blank. You may use this page for your work.

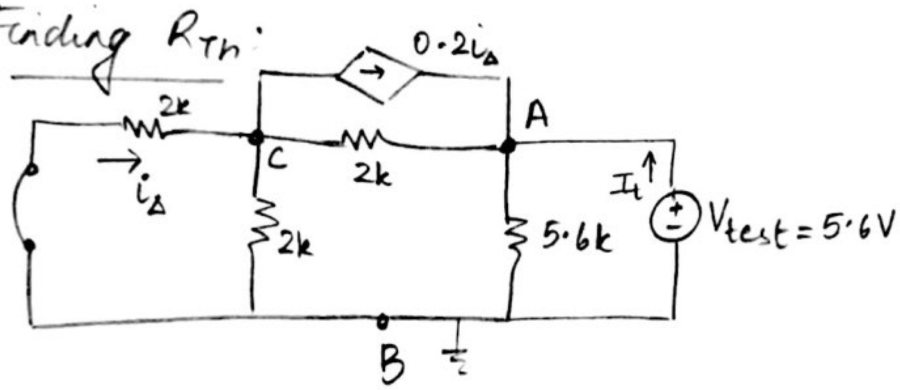
$$\Rightarrow \frac{-56 + 0.2V_C - V_C + V_A}{2k} + \frac{V_A}{5.6k} = 0$$

$$\Rightarrow -56\times 2.8 - 0.8V_C\times 2.8 + 3.8V_A = 0 \Rightarrow 3.8V_A - 2.24V_C = 156.8 \quad -(2)$$

$$\Rightarrow V_A = \underline{\underline{112V}} \quad \& \quad V_C = \underline{\underline{120V}}$$

$$\Rightarrow V_{Th} = V_A = \underline{\underline{112V}}$$

Finding R_{Th}:



$$i_\Delta = \frac{-V_C}{2k}$$

KCL @ C $\rightarrow \frac{V_C}{2k} + 0.2\left(\frac{-V_C}{2k}\right) + \frac{V_C}{2k} + \frac{V_C - 5.6V}{2k} = 0$

3pts.

$$\Rightarrow 2.8V_C = 5.6V$$

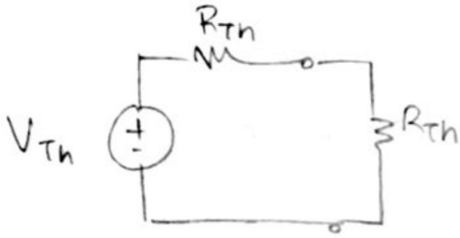
$$\Rightarrow V_C = 2V$$

$$I_{test} = \frac{V_A}{5.6k} + \frac{V_A - V_C}{2k} - 0.2\left(-\frac{V_C}{2k}\right)$$

$$= \frac{5.6V}{5.6k} + \frac{5.6-2}{2k} + \frac{0.2\times 2}{2K} = 1 + 1.8 + 0.2 = +3mA$$

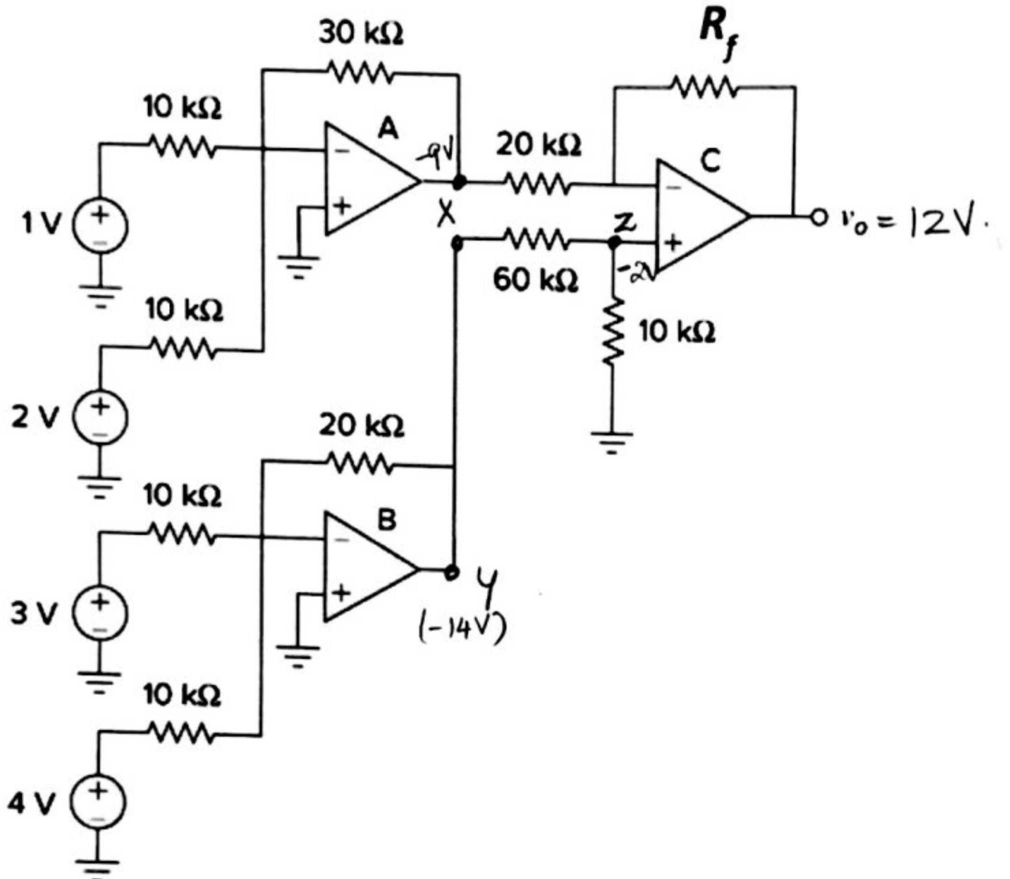
3pts.

$$\Rightarrow R_{Th} = \frac{V_{Test}}{I_{Test}} = \frac{5.6V}{3mA} = \underline{\underline{1.867\,k\Omega}}$$



4pts $\Rightarrow$ max power transfer $= \frac{V_{Th}^2}{4R_{Th}} = \frac{112^2}{4\times 1867} = \underline{\underline{1.68W}}$

3. Given that all the op-amps in the following circuit are ideal, what value of feedback resistor (R_f) will produce an output of 12V? *[25 points]*



R_f = $40\,k\Omega$

5pts. $V_x = 1V\left(-\frac{30}{10}\right) + 2V\left(-\frac{30}{10}\right) = -3 - 6 = \underline{\underline{-9V}}$

5pts $V_y = 3V\left(-\frac{20}{10}\right) + 4V\left(-\frac{20}{10}\right) = -6 - 8 = \underline{\underline{-14V}}$

5pts $\Rightarrow V_z = V_{10k\Omega} = V_y\left(\frac{10k}{70k}\right) = -14 \times \frac{1}{7} = \underline{\underline{-2V}}$

$i_{20k} = i_{R_f}$

5pts $\Rightarrow \frac{V_x - V_z}{20k} = \frac{V_z - V_o}{R_f} \Rightarrow \frac{-9+2}{20k} = \frac{-2-12}{R_f}$

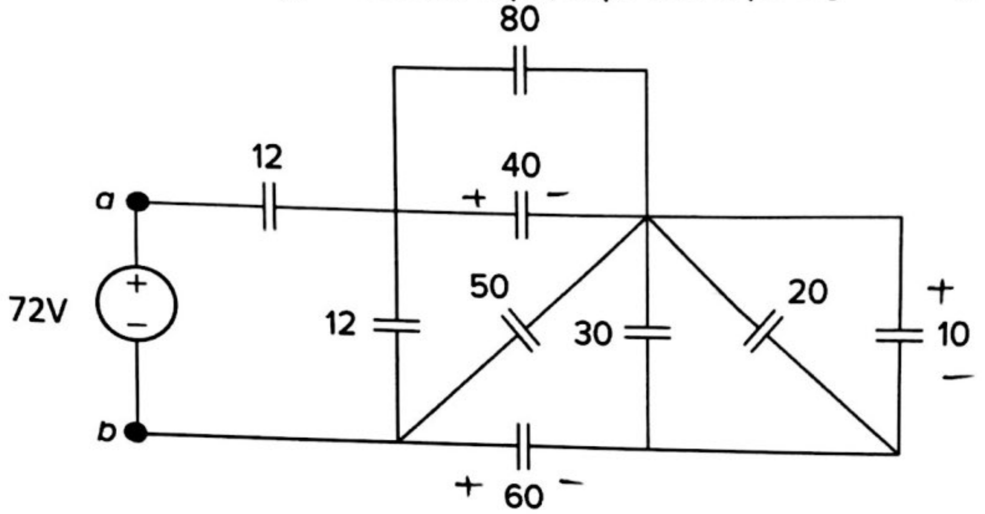
Page intentionally left blank. You may use this page for your work.

$$\Rightarrow R_f = \frac{-14}{-7} \times 20k$$

$$= +2 \times 20k$$

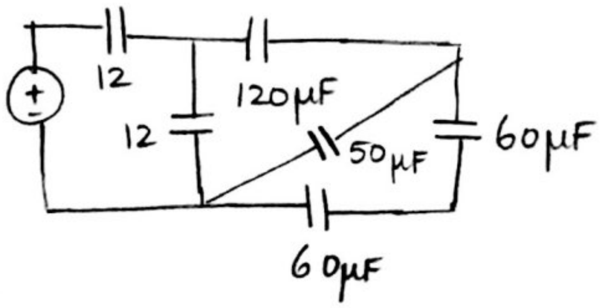
(if they work it correctly from their prev. equation) 5pts $= \underline{\underline{40k\Omega}}$

4. For the circuit shown below, all the capacitances are given in μF.
   A. Find the equivalent capacitance between terminals a &b, as seen by the voltage source. *[10 points]*
   B. Find the voltage across the 40μF, 60μF and 10μF capacitors. *[15 points]*



2pts → $10 \| 20 \| 30 = 60\mu F$

$80 \| 40 = 120\mu F$.



~~In~~ = ______

$C_{eq} = 10\mu F$

$V_{40\mu F} = 4.8V$

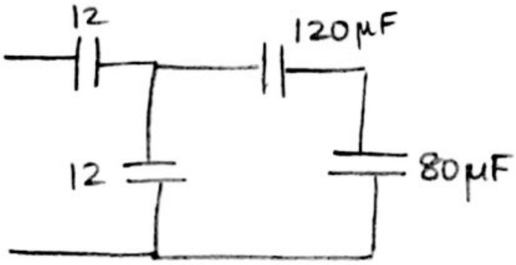
$V_{60\mu F} = 3.6V$

$V_{10\mu F} = 3.6V$

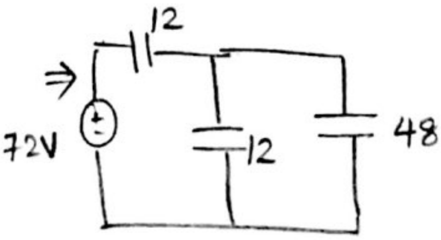
2pts ⇒ 60 in series with 60μF = 30μF.

2pts $30 \| 50 = 80\mu F$

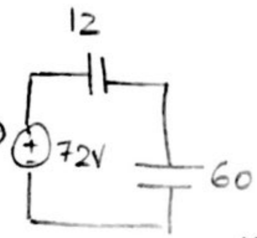
$\frac{1}{120} + \frac{1}{80} = \frac{1}{48}$ 2pts.



⇒



⇒



2pts.

⇒ $C_{eq} = 10\mu F$

Page intentionally left blank. You may use this page for your work.

$V_{60\mu F} = 72\left(\frac{10\mu F}{60\mu F}\right)$

3pts. $= \underline{\underline{12V}}$

$V_{C_1} = V_{total}\left(\frac{C_{eq}}{C_1}\right)$

3pts. $V_{80\mu F} = 12V\left(\frac{48}{80}\right) = \underline{\underline{7.2V}}$

3pts → $V_{120\mu F} = 12V\left(\frac{48}{120}\right) = \underline{\underline{4.8V}}$

↓ $V_{40\mu F} = V_{120\mu F} = \underline{\underline{4.8V}}$

3pts. $V_{60\mu F} = 7.2V\left(\frac{30}{60}\right) = \underline{\underline{3.6V}}$

3pts. $V_{10\mu F} = V_{60\mu F} = \underline{\underline{3.6V}}$

5. Complete the following statements or state whether they are true or false: *[Bonus 5 points]*
   A. Inductor stores energy in its magnetic field.
   B. Voltage cannot change instantly for a Capacitor.

$L \propto N^2$.

   C. Inductance (L) is proportional to the number of turns (N) in the coil. (True/False)
   D. You want to build an ideal step-down transformer rated 240/120Vrms. If the primary has 100 turns, how many turns should the secondary have? 50 turns
   E. What is the energy stored in a 60μF capacitor if it has a 3.6V across it?

$$W = \frac{1}{2} C V^2$$
$$= \frac{1}{2} \times 60\mu \times 3.6^2$$
$$= 0.388\, mJ.$$