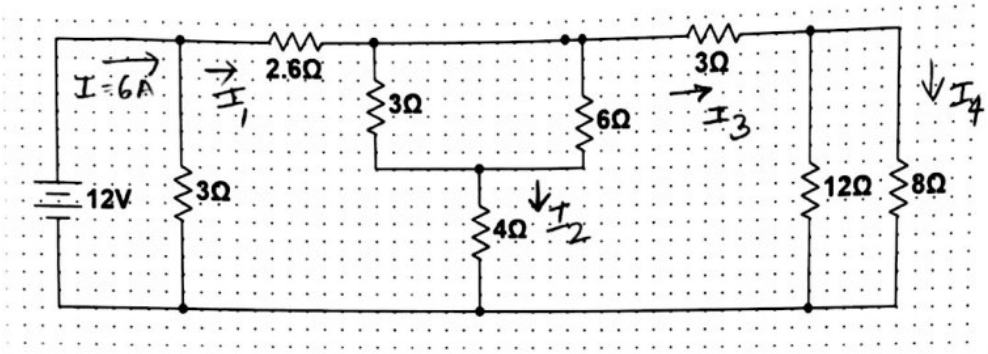
1. Find the power dissipated in the 4Ω and 8Ω resistor. *[20 points]*



$P = I^2R$

$P_{4\Omega} = (I_2)^2 R = +5.11\ W$

$P_{8\Omega} = (I_4)^2 R = +2.16\ W$ (2)

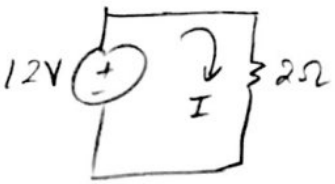
$$R_{eq} = \left(\left\{ \left[(12 \| 8) + 3 \right] \| (3 \| 6 + 4) \right\} + 2.6 \right) \| 3$$

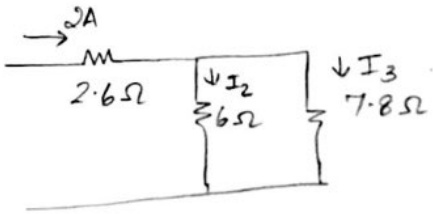
$$= \{ (4.8 + 3) \| (2 + 4) + 2.6 \} \| 3$$

$$= 6 \| 3$$

$$= 2\Omega$$

$$I = \frac{12V}{2\Omega} = 6A$$





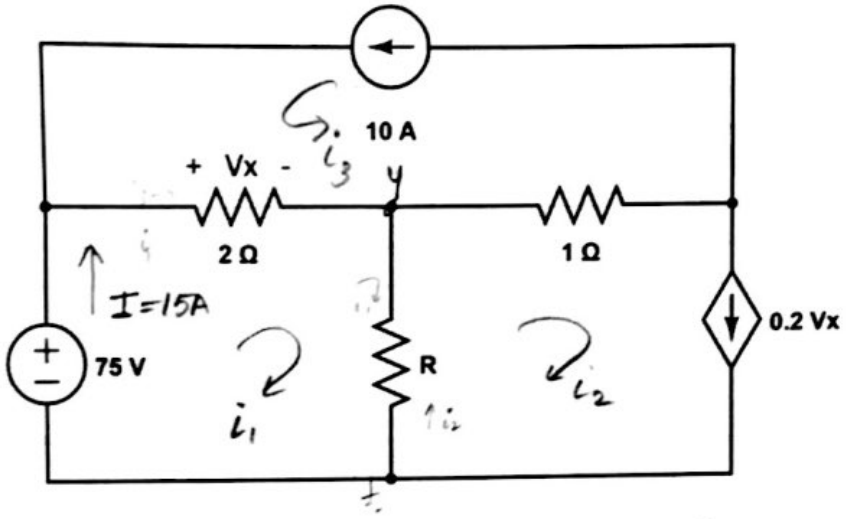
(10) $I_1 = 6A \left(\frac{2\Omega}{6\Omega} \right) = 2A$

(4) $I_2 = 2A \left(\frac{3.4\Omega}{6\Omega} \right) = 1.13A$

$I_3 = 2A \left(\frac{3.4\Omega}{7.8\Omega} \right) = 0.87A$

(4) $I_4 = 0.87A \left(\frac{4.8\Omega}{8\Omega} \right) = 0.52A$

2. Given that the **75V** source is supplying **1125W** power; find the value of the unknown resistor, R. *[15 points]*



R = 5Ω

$P = VI \Rightarrow I = P/V = 1125/75 = 15A$

(5) $\Rightarrow i_1 = 15A$ & $i_3 = 10A$

(5) $i_2 = 0.2V_x = 0.2[2(i_1 + i_3)] = 0.4 i_1 + 0.4 i_3$

$\Rightarrow i_2 = 0.4 \times 15 + 0.4 \times 10$

$= 10A$

(5) KVL @ mesh ① $\longrightarrow$

$-75 + 2(i_1 + i_3) + R(i_1 - i_2) = 0$

$\Rightarrow -75 + 2(15+10) + R(15-10) = 0$

$\Rightarrow -75 + 50 + 5R = 0$

$\Rightarrow R = \frac{25}{5} = 5\Omega$

OR: $i_{2\Omega} = 15 + 10 = 25A$

(3) $\Rightarrow V_x = 25A \times 2\Omega = 50V$

$\Rightarrow V_y = 75V - 50V = 25V$

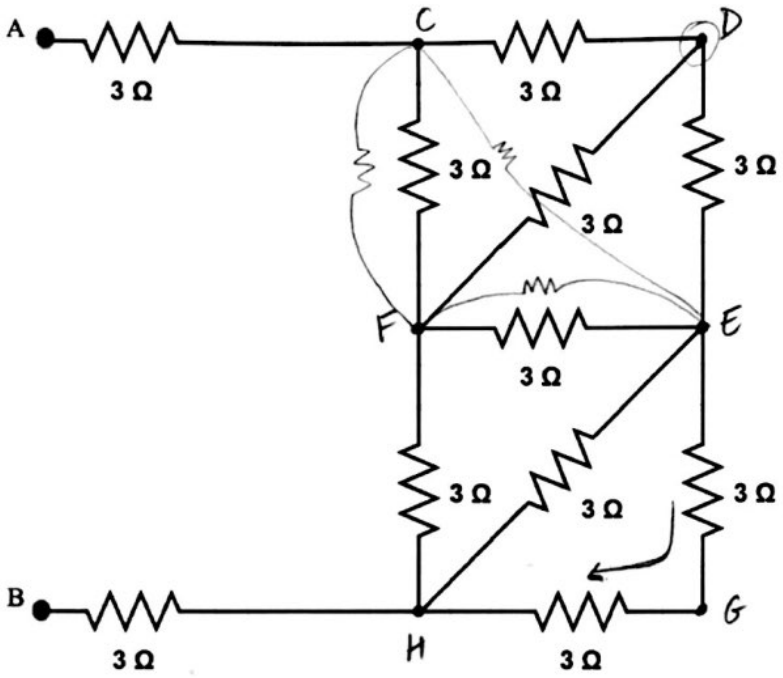
& $0.2V_x = 0.2 \times 50 = 10A$ (2)

(1) $\Rightarrow i_{1\Omega} = 10A + 10A = 20A$

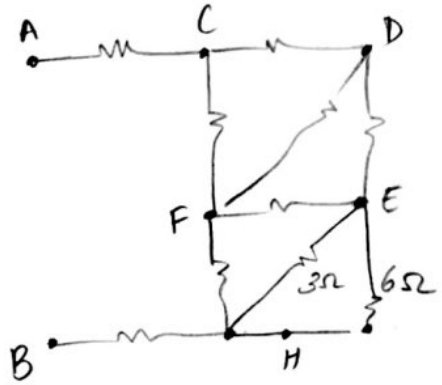
$\Rightarrow i_R = 25A - 20A = 5A \Rightarrow R = \frac{25V}{5A} = 5\Omega$

grading – 8 pts ea. connection
– 4 pt. calculation/result

3. Find the equivalent resistance (R_{AB}) between nodes A and B. *[20 points]*



(1)

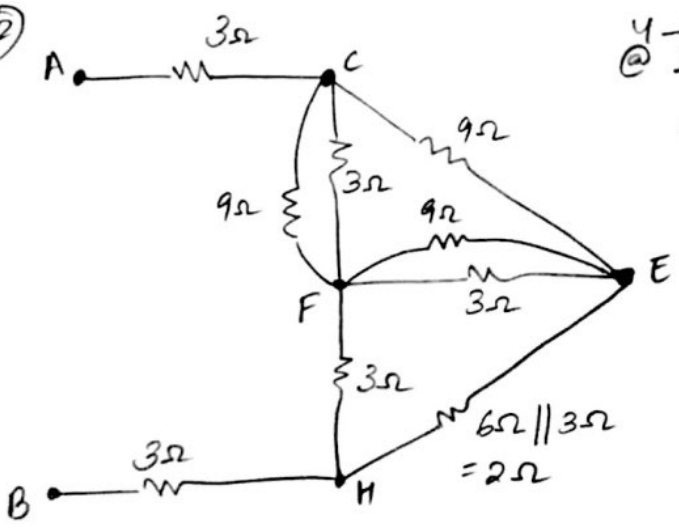


$R_{AB} \cong \frac{9\Omega}{}$

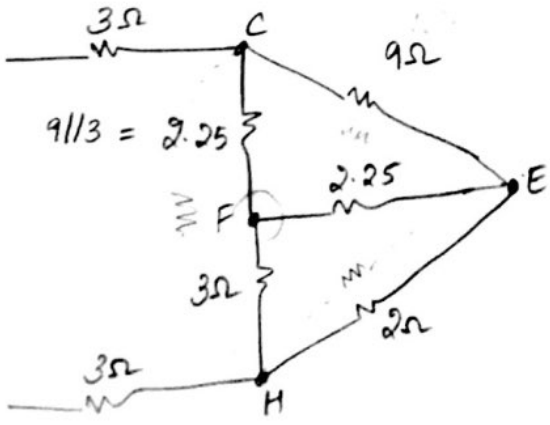
Y → Δ: sum of products / opp. @ D. $= \frac{3\times3+3\times3+3\times3}{\text{opp.}} = \frac{27}{\text{opp.}}$

$R_{CE} = \frac{27}{3} = 9\Omega$ $R_{CF} = 9\Omega$ $R_{FE} = 9\Omega$

(2)



(3) ⇒



Δ → Y: prod. of adj / sum of all

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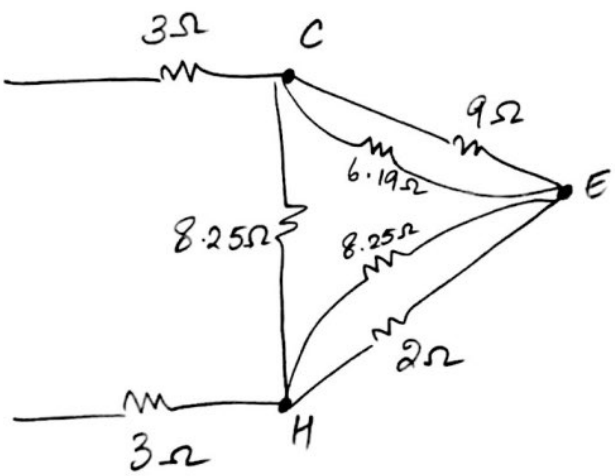
④ $Y \rightarrow \Delta$ @ F : $\dfrac{2.25\times 2.25 + 2.25\times 3 + 3\times 2.25}{opp} = \dfrac{18.5625}{opp}$

$$R_{CE} = \frac{18.5625}{3} = 6.1875\,\Omega$$

$$R_{EH} = \frac{18.5625}{2.25} = 8.25\,\Omega$$

$$R_{CH} = \frac{18.5625}{2.25} = 8.25\,\Omega$$

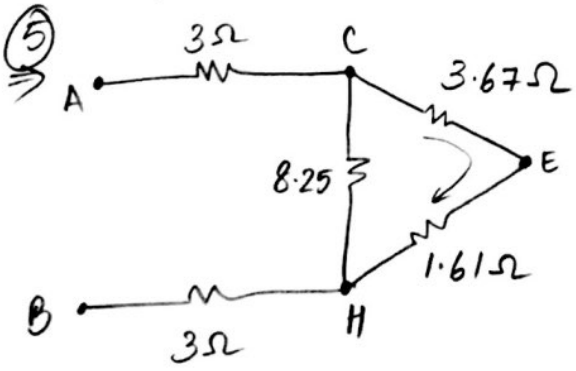
④ ⇒



$Req(CE) = 6.19 \,||\, 9 = 3.67\,\Omega$

$Req(EH) = 8.25 \,||\, 2 = 1.61\,\Omega$

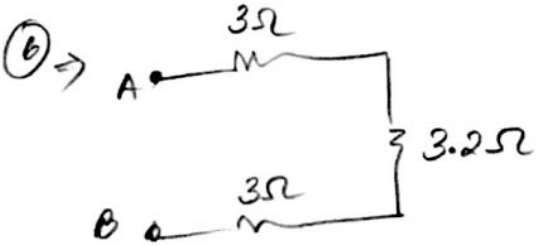
⑤ ⇒



$3.67 + 1.61 = 5.28\,\Omega$

$Req(CH) = 8.25 \,||\, 5.28 = 3.2\,\Omega$

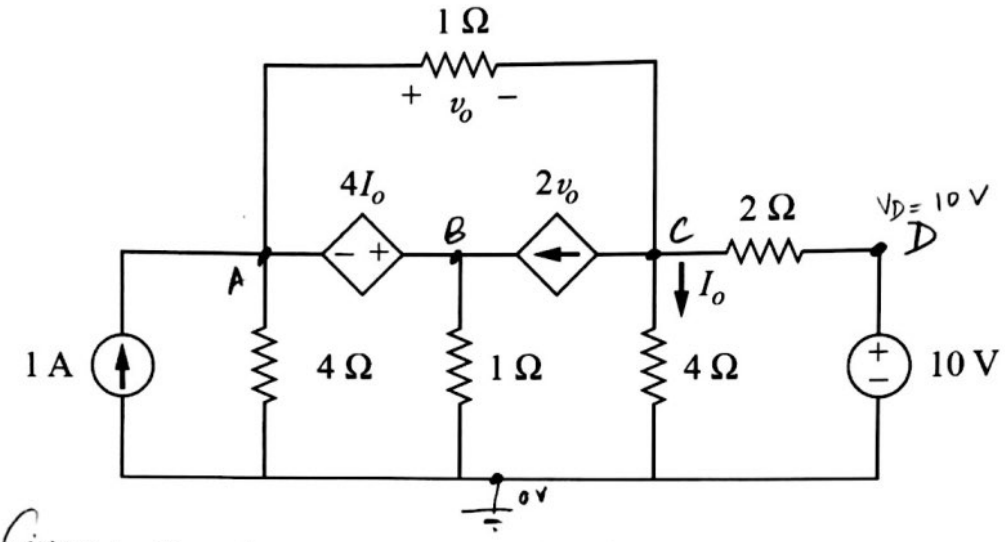
⑥ ⇒



$Req(AB) = 3 + 3.2 + 3 = 9.2\,\Omega$

Alexander & Sadiku P#3.31

4. Find v_o and $\mathbf{I_o}$ for the following circuit. *[20 points]*



v_o = 5.09 V

I_o = −0.03 A

(4) Given: $V_B - V_A = 4I_o$ & $I_o = \frac{V_C}{4\Omega}$

$\Rightarrow V_B - V_A = 4\frac{V_C}{4}$

$\Rightarrow V_A(-1) + V_B(1) + V_C(-1) = 0$ ——— (1)

(2) Also, $v_o = V_A - V_C$.

$V_D = 10\,V$

KCL @ supernode A & B ⟶

(5) $-1 + \frac{V_A}{4\Omega} + \frac{V_A - V_C}{1\Omega} + \frac{V_B}{1\Omega} - 2(V_A - V_C) = 0$

$\Rightarrow V_A\left(\frac{1}{4} + 1 - 2\right) + V_B + V_C(-1+2) = 1$

$\Rightarrow V_A(-0.75) + V_B + V_C(1) = 1$ ——— (2)

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KCL @ node C ⟶

(5)

$$\frac{V_C - V_A}{1\Omega} + 2(V_A - V_C) + \frac{V_C}{4\Omega} + \frac{V_C - 10}{2\Omega} = 0$$

$$\Rightarrow V_A(-1+2) + V_C(1-2+1/4+1/2) = 5$$

$$\Rightarrow V_A(1) + V_C(-0.25) = 5 \quad \text{——— (3)}$$

(4)

$$\Rightarrow \begin{bmatrix} -1 & 1 & -1 \\ -0.75 & 1 & 1 \\ 1 & 0 & -0.25 \end{bmatrix} \begin{bmatrix} V_A \\ V_B \\ V_C \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \\ 5 \end{bmatrix}$$

Solving ⟶ $V_A = 4.97V$

$V_B = 4.85V$

$V_C = -0.12V$

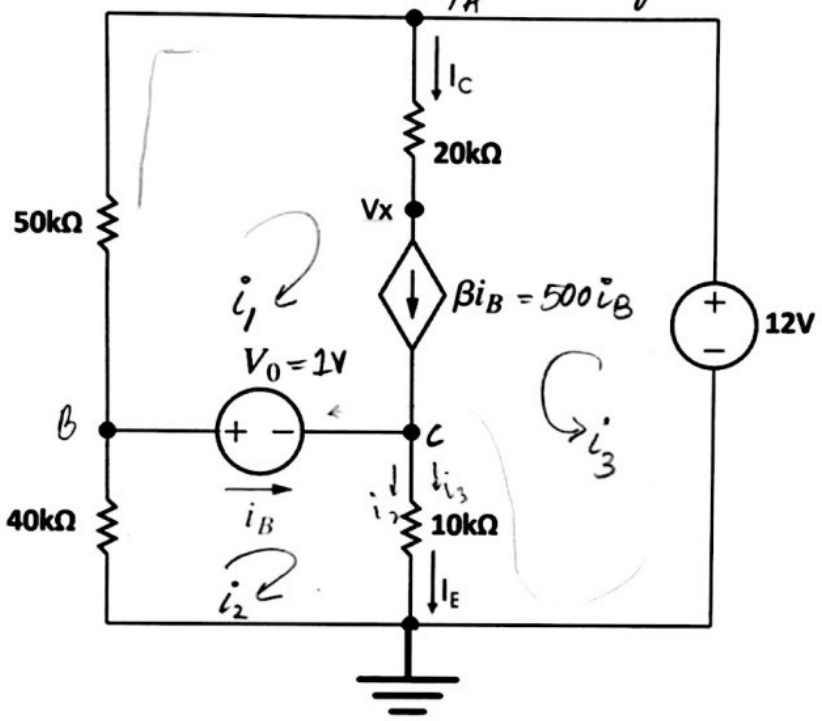
$$V_o = V_A - V_C = \underline{5.09\,V}$$

$$I_o = \frac{V_C}{4\Omega} = -0.03A = \underline{-30mA}$$

5. You build the following amplifier using a transistor (BJT) having a threshold voltage, **Vo = 1V**, and gain **β = 500**.

a) Find the base current (i_B), collector current (I_C), and emitter current (I_E). *Hint: Use mesh analysis.* *[25 points]*

b) Find Vx with respect to ground. *[Bonus 5 points]*



i_B = 1μA

I_C = 0.43mA

I_E = 0.431mA

V_X = 3.4V

(3) Given: $\beta i_B = i_1 + i_3$.

(3) & $i_B = i_2 - i_1$

$\Rightarrow \beta(i_2 - i_1) = i_1 + i_3$ [substituting $\beta = 500$]

$\Rightarrow i_1 + i_3 - 500 i_2 + 500 i_1 = 0$

$\Rightarrow 501 i_1 - 500 i_2 + i_3 = 0$ ——— (1)

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KVL @ supermesh 1 & 3 $\longrightarrow$

$$(50k)\,i_1 + 12 - 10k(i_2 + i_3) - 1 = 0$$

(6) $\Rightarrow (50k)\,i_1 - 10k \cdot i_2 - 10k \cdot i_3 = -11$ —— (2)

KVL @ mesh 2 $\longrightarrow$

$$40k \cdot i_2 + 1 + 10k\,(i_2 + i_3) = 0$$

(5) $\Rightarrow 50k \cdot i_2 + 10k \cdot i_3 = -1$ —— (3)

(2)
$$\begin{bmatrix} 501 & -500 & 1 \\ 50k & -10k & -10k \\ 0 & 50k & 10k \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 0 \\ -11 \\ -1 \end{bmatrix}$$

solving $\longrightarrow$

$i_1 = -0.134\,mA$

$i_2 = -0.133\,mA$

$i_3 = 0.564\,mA$

(2) $\Rightarrow i_B = i_2 - i_1 = +0.001 = \underline{\underline{+1\,\mu A}}$

(6) $I_C = i_1 + i_3 = \underline{0.43\,mA}$ or $I_C = 500\,i_B = 500\mu A = \underline{\underline{0.5\,mA}}$

(2) $I_E = i_2 + i_3 = \underline{\underline{0.431\,mA}}$ sanity check $I_E = I_B + I_C$ ✓

(5) $V_x = 12 - I_C \cdot 20k$

$= \underline{\underline{3.4V}}$ or $\underline{\underline{2V}}$ depending on $I_C = 0.43mA$ or $0.5mA$