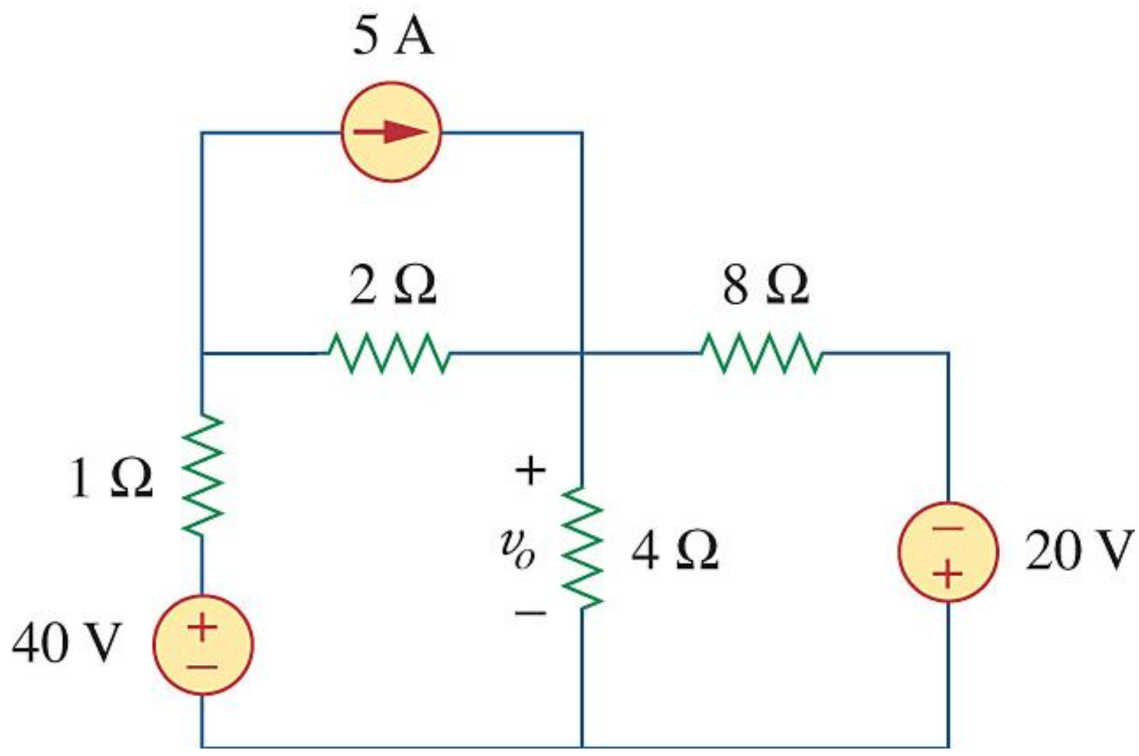
Big Question

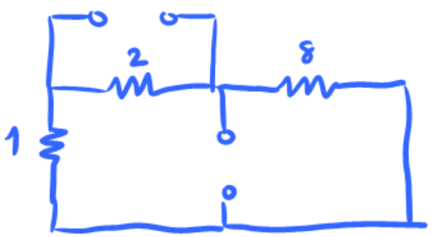
Find v_0 using

1. Nodal Analysis
2. Mesh Analysis
3. Superposition
4. Source Transformation
5. Thevenin equivalent
6. Norton equivalent

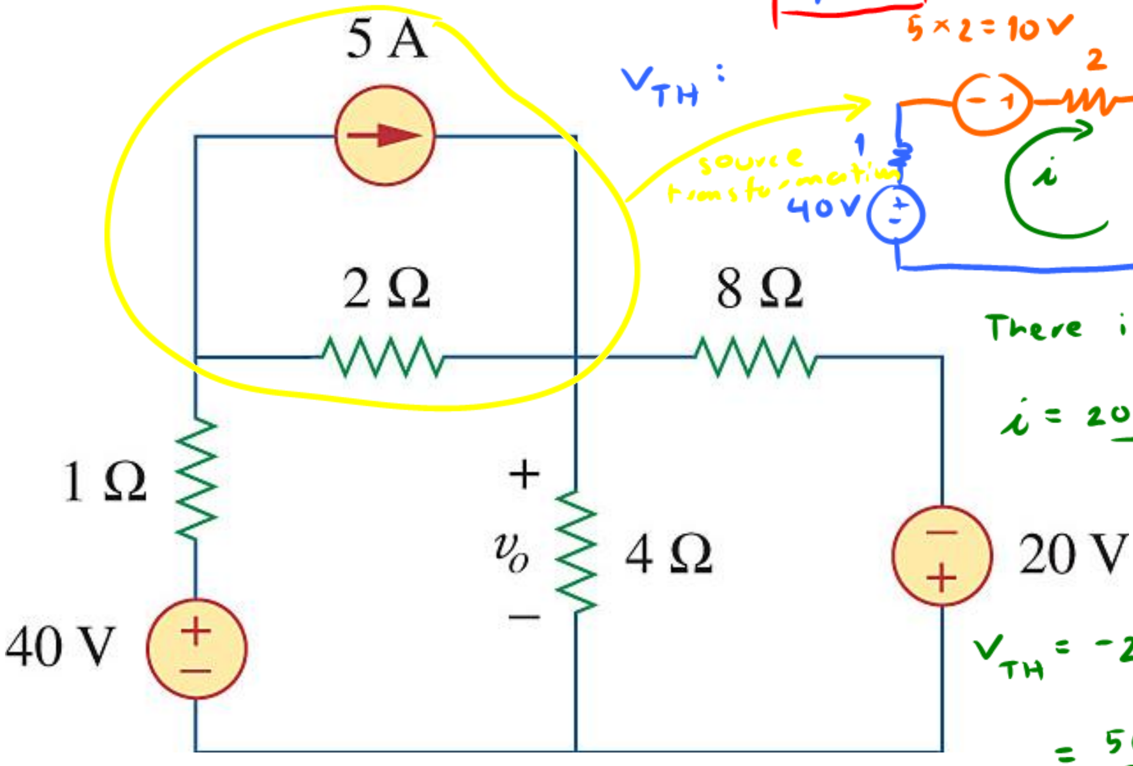


(5) Thevenin Equivalent

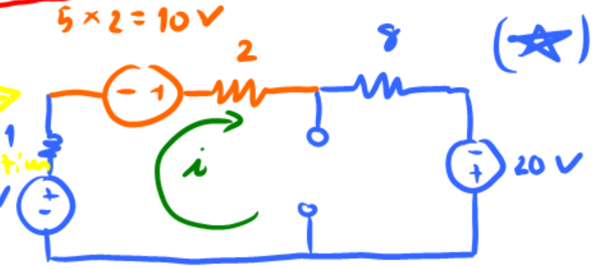
R_{TH} :



$$R_{TH} = 8 // (2+1)\ \Omega$$
$$= 8 // 3 = \frac{8 \times 3}{8+3}$$
$$= \boxed{\frac{24}{11}\ \Omega}$$



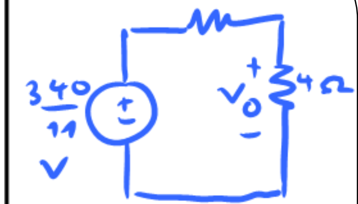
V_{TH} :



There is only one loop.

$$i = \frac{20+40+10}{11} = \frac{70}{11}$$

$$V_{TH} = -20 + \frac{70}{11} \times 8$$
$$= \frac{560-220}{11} = \boxed{\frac{340}{11}\ V}$$

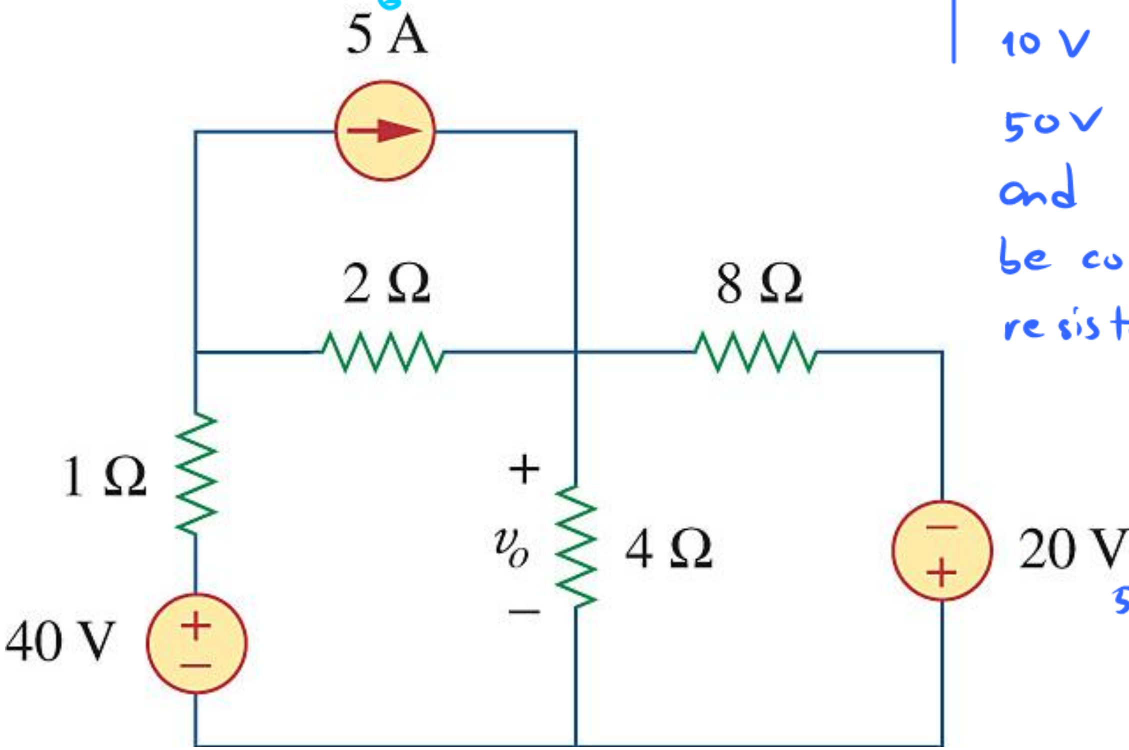


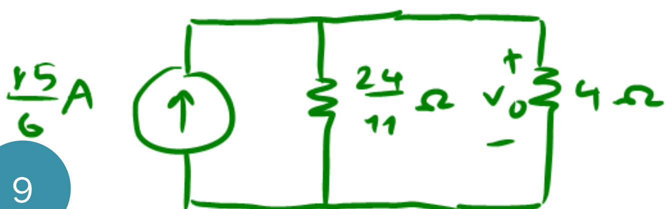
$$V_0 = \frac{4}{4+\frac{24}{11}} \times \frac{340}{11}$$
$$= \frac{4 \times 340}{68}$$
$$= \boxed{20\ V}$$

⑥ Norton Equivalent

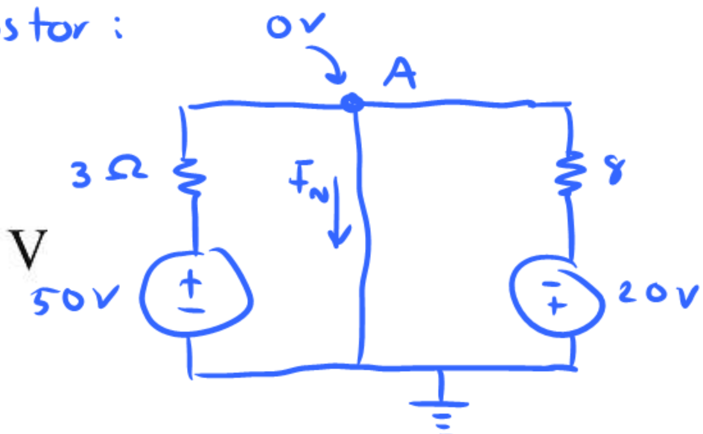
R_N : Same as R_{TH} above $= \frac{24}{11}\ \Omega$

$$I_N = \frac{V_{TH}}{R_N} = \frac{340/11}{24/11} = \frac{85}{6}\ A$$





Alternatively, to find I_N directly, we perform one source transformation as in the Thevenin case above. Then we combine 40V and 10 V voltage sources into a 50V voltage source. The 1Ω and 2Ω resistors can also be combined into one 3Ω resistor:



KCL @ A : $I_N + \frac{(0-50)}{3} + \frac{(0-(-20))}{8} = 0$

$I_N = \frac{85}{6}$ A

$$v_o = \frac{85}{6} \times \left(\frac{24}{11} // 4\right) = \frac{85}{6} \times \frac{24}{17} = 20\ V$$