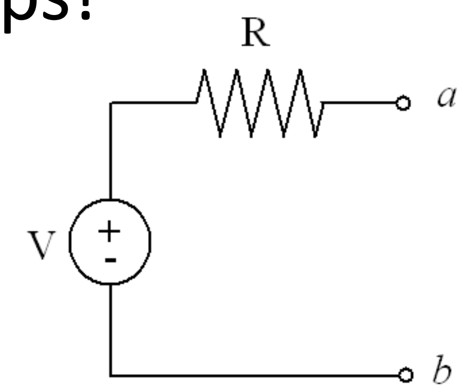
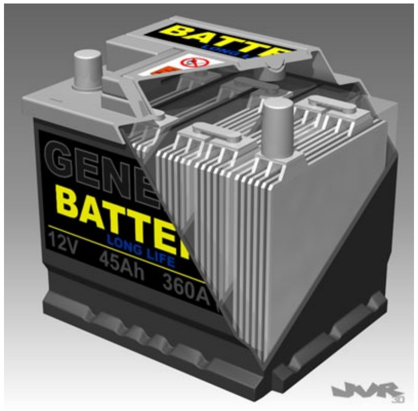
Theorems – 3

more Thevenin; Norton

Everyday Example

- Car battery – 12.6 volts
- Can provide 100-200 amps!
- Thévenin model:
  - 12.6 volt source
  - 0.05-0.2 Ω resistance





- "Dead" when resistance increases (age/cold)
- Short circuit measurement ? (!)
  - How to test?

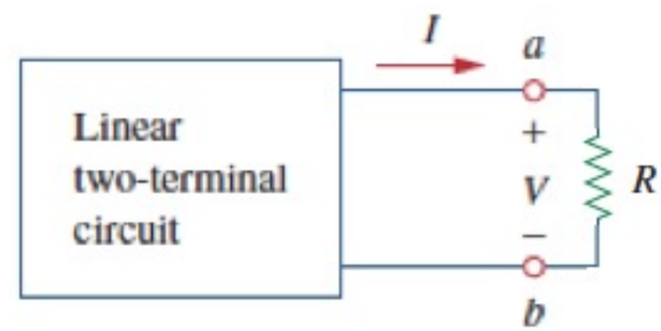
Alternative Method – Known Load

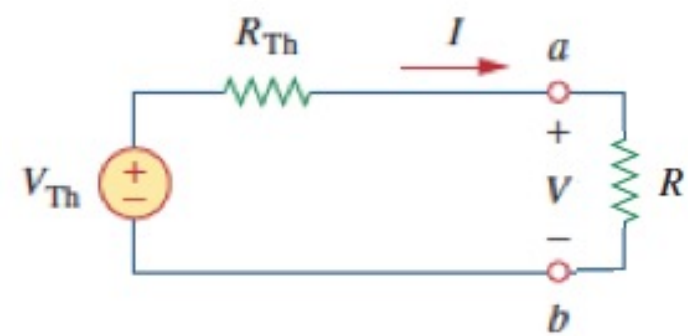
- Connect a known resistance across the terminals

$$V = \frac{R}{R_{TH} + R} V_{TH}$$

- Original relationships

$$V_{oc} = V_{TH}$$
$$V_{TH} = I_{sc} R_{TH}$$





Car battery problem – version 1:

- Open circuit test: 12.6 volts across the terminals

- 10 Ω precision resistor load: 12.46 volts

Solution 1:

– Open circuit test: 12.6 volts across the terminals

$$V_{Th} = V_{oc} = 12.8 \text{ volts}$$

– 10 Ω precision resistor load: 12.46 volts

$$V = \frac{R}{R_{TH} + R} V_{TH}$$

$$12.46 = \frac{10}{R_{TH} + 10} 12.6$$

$$R_{TH} = 0.112\ \Omega$$

Car battery problem – version 2:

- 100 Ω precision resistor load: 12.45 volts
- 10 Ω precision resistor load: 12.2 volts

Solution 2:

– 100 Ω precision resistor load: 12.45 volts

– 10 Ω precision resistor load: 12.2 volts

$$12.45 = \frac{100}{R_{TH} + 100} V_{TH} \quad \Rightarrow \quad 100\, V_{TH} - 12.45\, R_{TH} = 1245$$

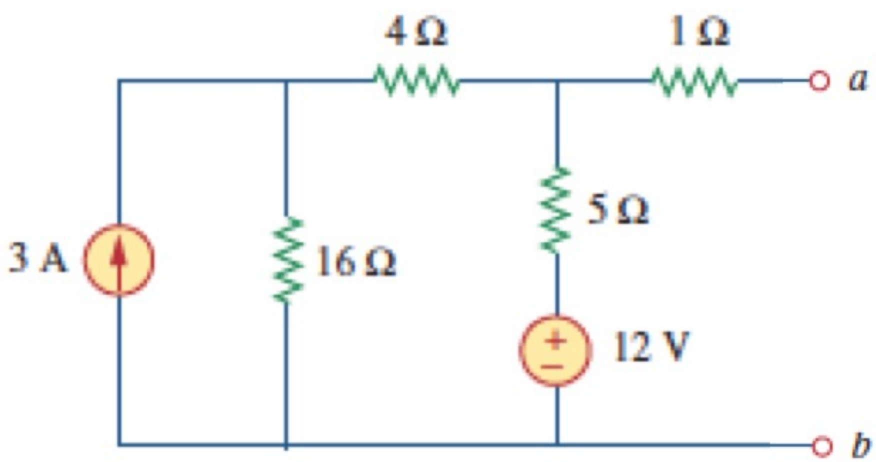
$$12.2 = \frac{10}{R_{TH} + 10} V_{TH} \quad \Rightarrow \quad 10\, V_{TH} - 12.2\, R_{TH} = 122$$

Solving

$$V_{TH} = 12.48 \text{ volts} \qquad R_{TH} = 0.228\ \Omega$$

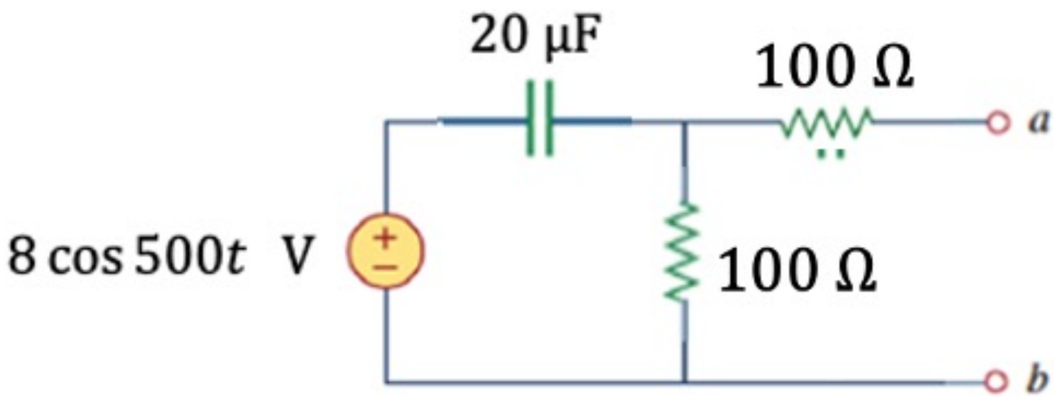
"Ohmmeter" Test for R_{Th}

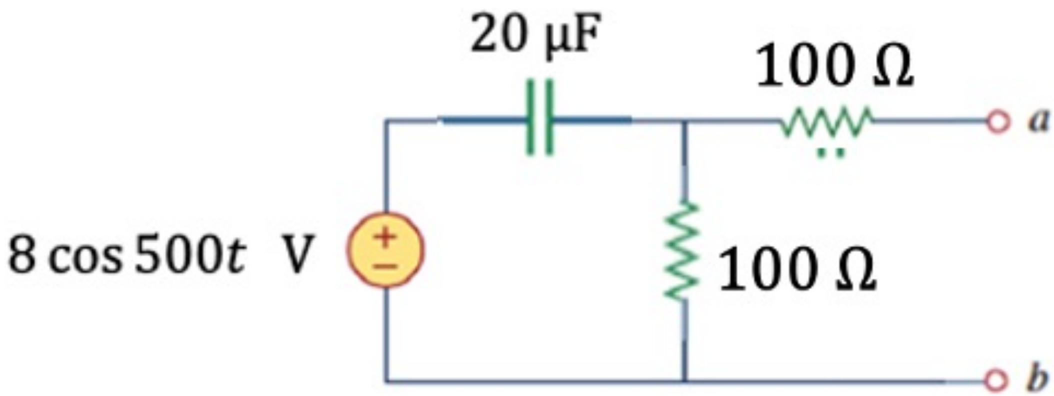
- If **no** dependent sources, then
  - Turn off independent sources
  - Compute equivalent resistance looking into terminals *a*-*b*



$19.2\ V, 5\ \Omega$

Thévenin and Phasors

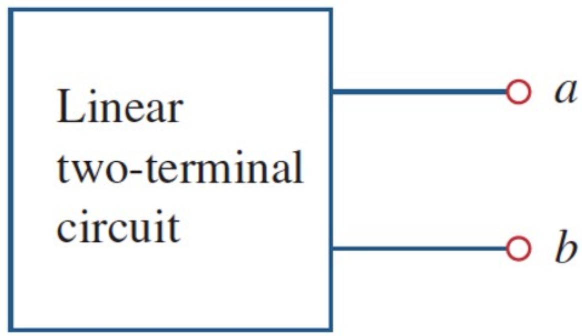




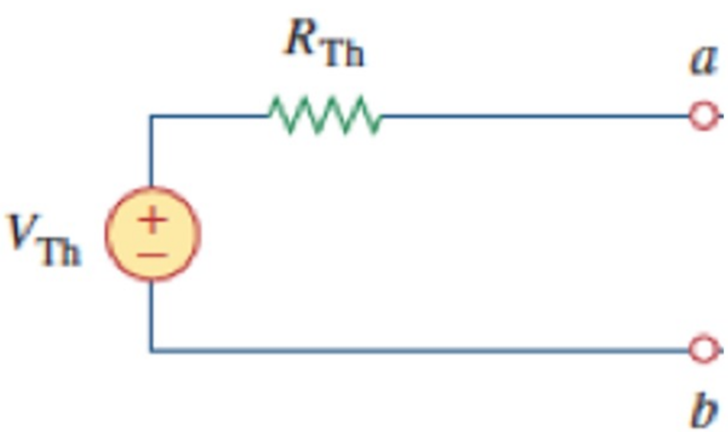
$4\sqrt{2}\ \cos(500t + 45°)\ V,$
$150\ \Omega, 40\ \mu F$

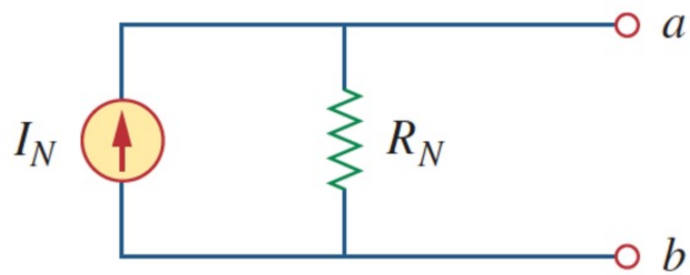
Norton Equivalent

- Recall source transformations, then

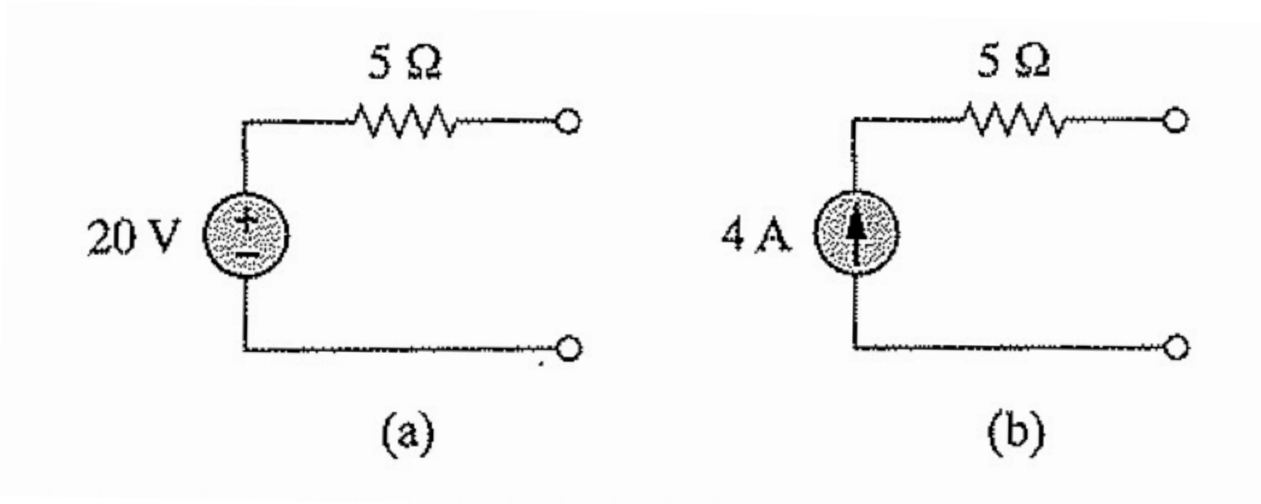


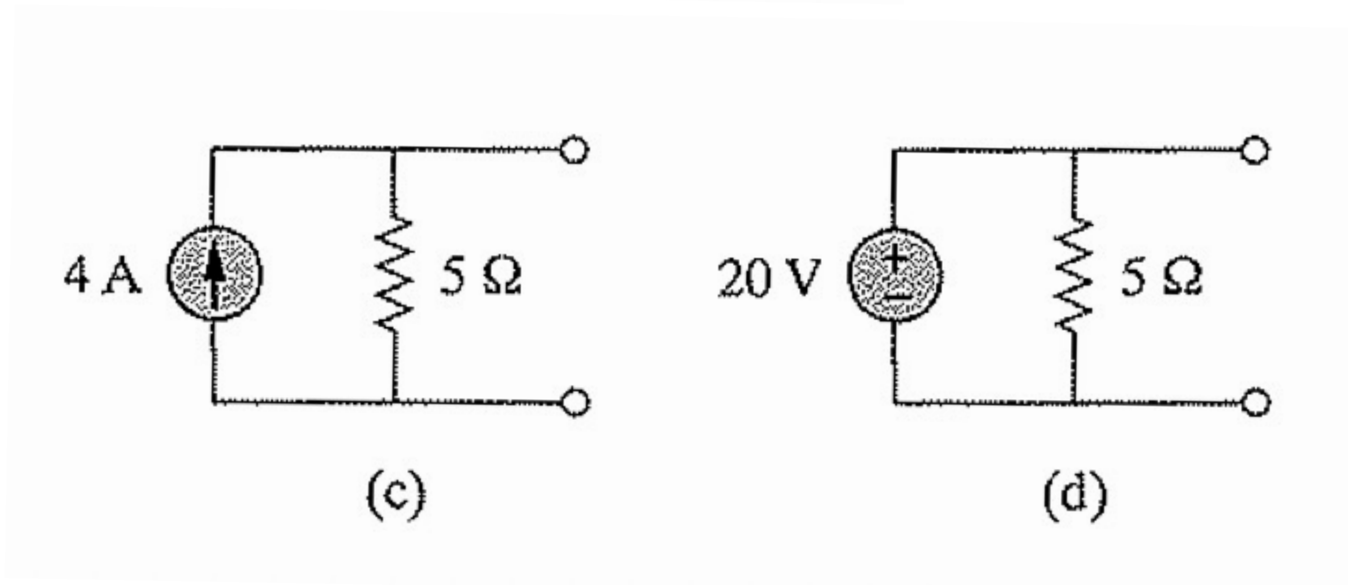
$$R_N = R_{TH}$$
$$I_n = I_{SC}$$



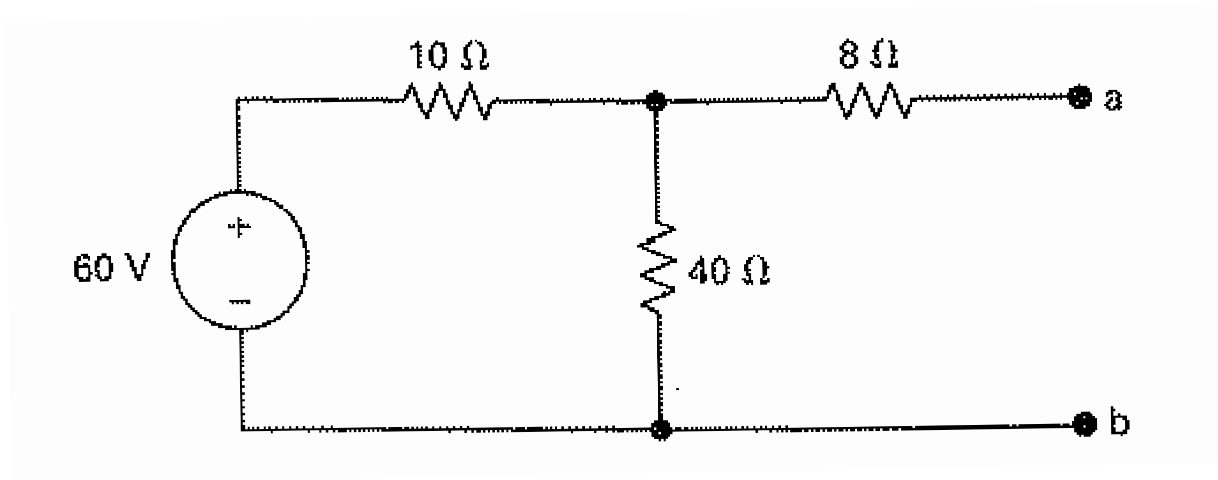


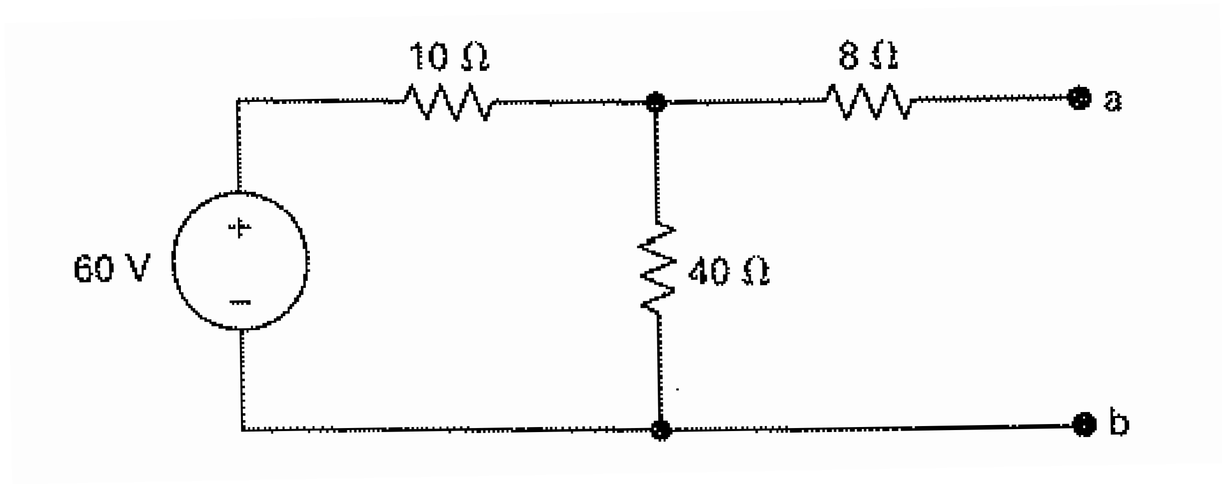
Example: which 2 are equivalent





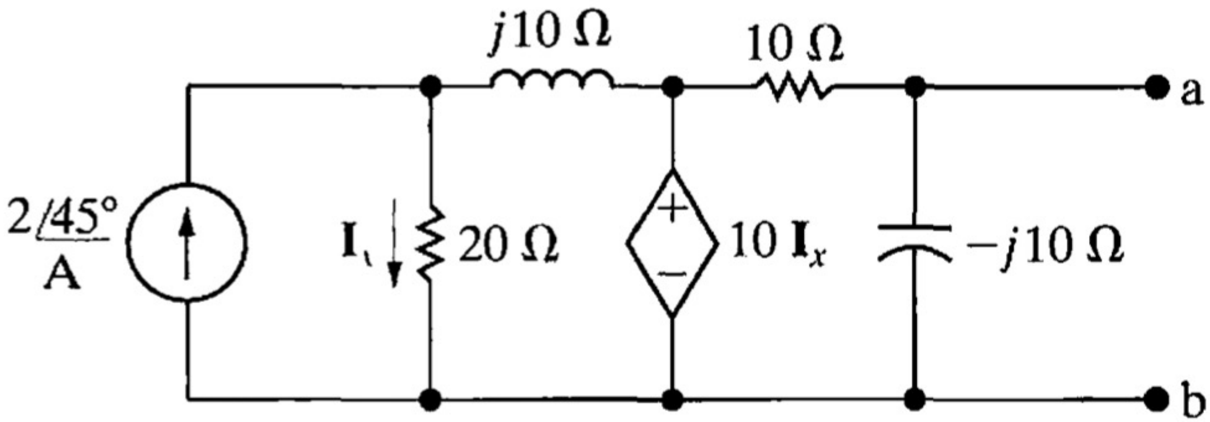
Example: Find I_N and R_N

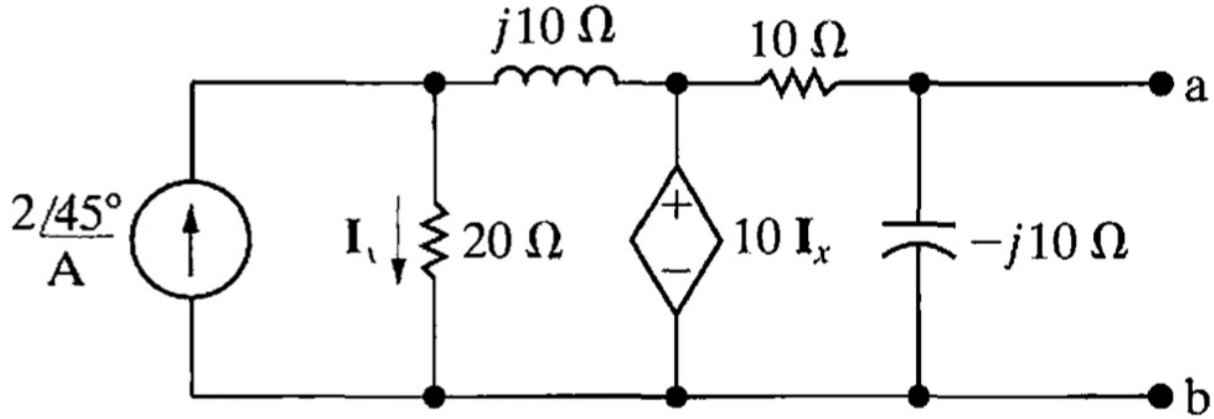




$I_N = 3\ A, R_N = 16\ \Omega$

Example: Find V_{Th} and Z_{Th} in phasor form

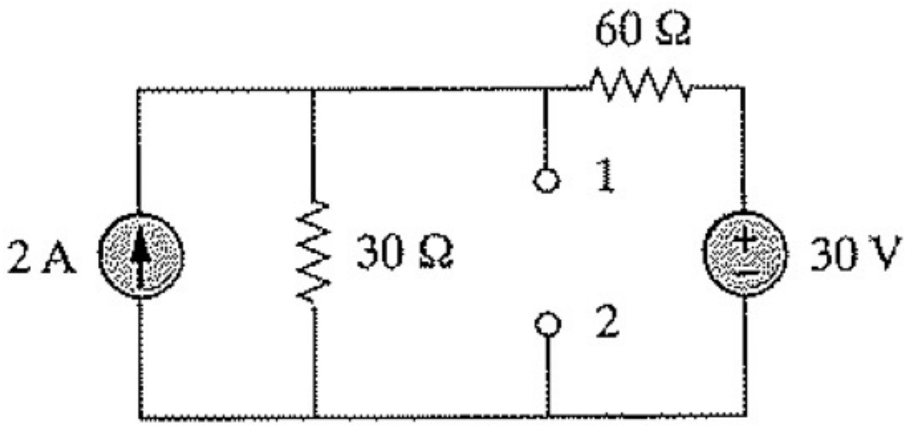




$10\ \angle 45°\ V, 5 - 5j\ \Omega$

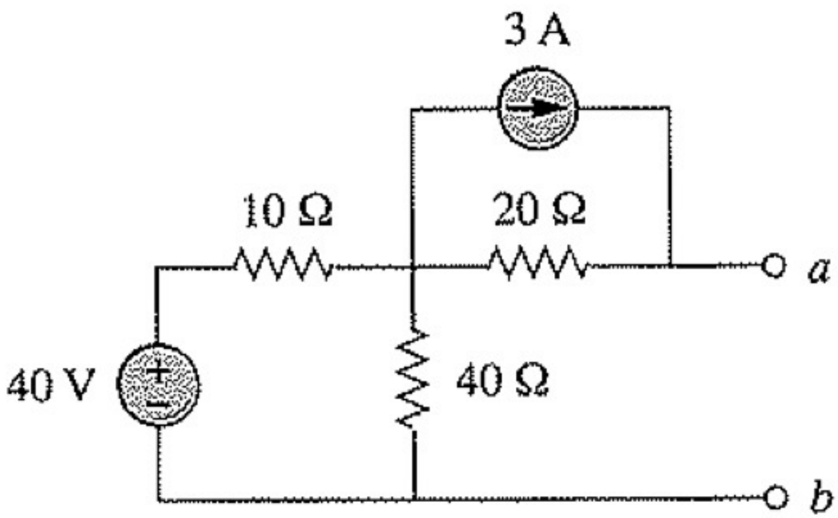
$50\ V, 20\ \Omega, 2.5\ A$

Practice problem: find Thevenin and Norton

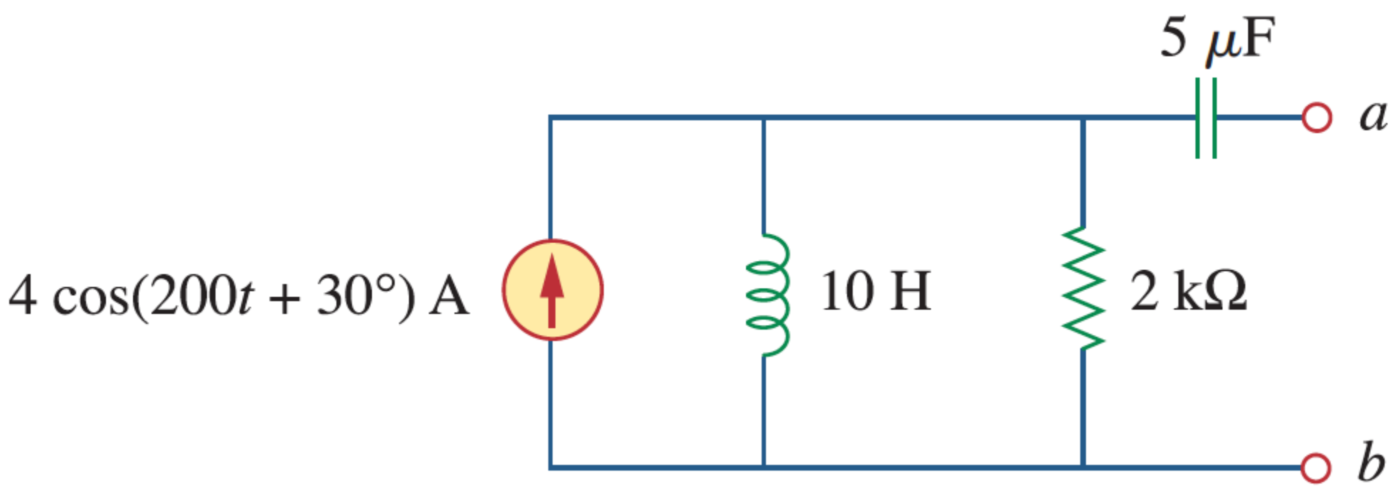


$92\ V, 28\ \Omega, 3.29\ A$

Practice problem: find Thevenin and Norton



Practice problem: find the Thevenin and Norton models

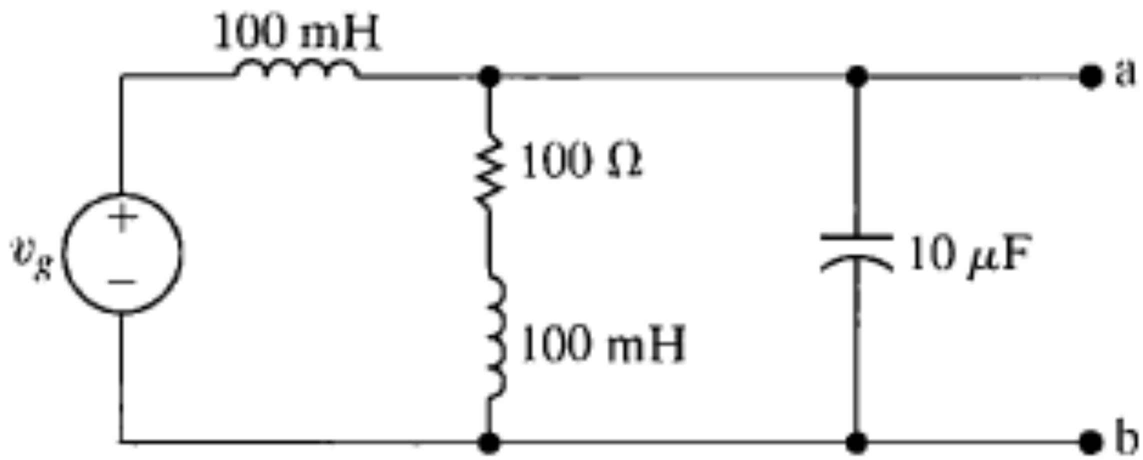


$4000\sqrt{2}\cos(200t + 75°)\ V,$

$1000\ \Omega,$

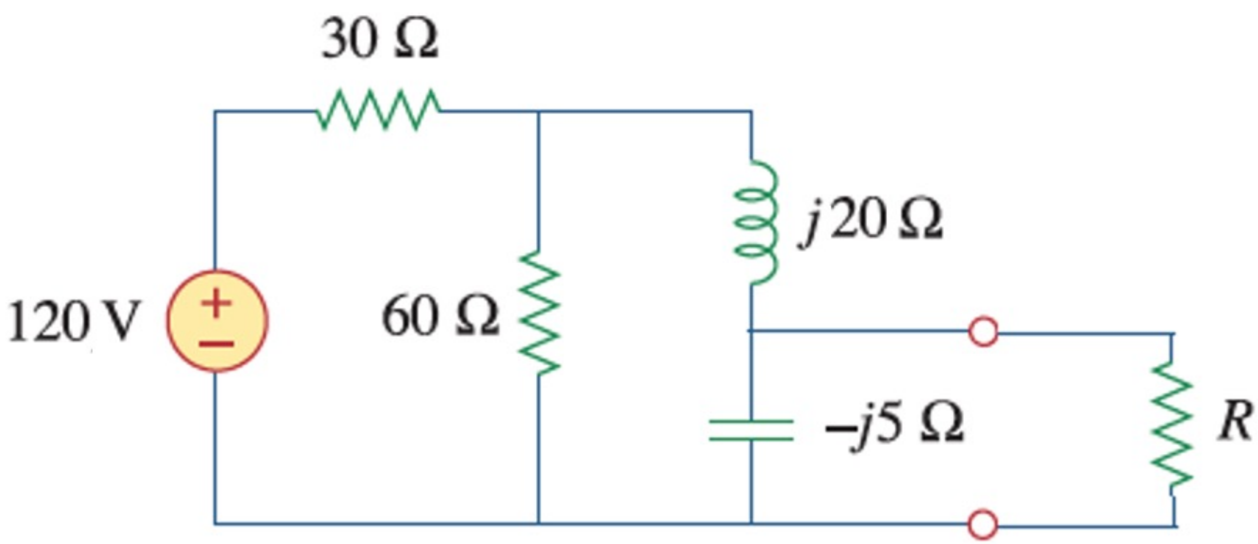
$4\sqrt{2}\cos(200t + 75°)\ A$

Practice problem: find the Thevenin and Norton models if $v_g(t) = 247.49 \cos(1000t + 45°)$ V



$350 \cos 1000t \ V,$
$100\ \Omega, 100\ mH,$
$2.475 \cos(1000t - 45°)\ A$

Practice problem: find the magnitude of the current through R as a function of R – hint: first find the Thevenin equivalent



$$\frac{16}{\sqrt{(R+0.8)^2+5.6^2}}$$