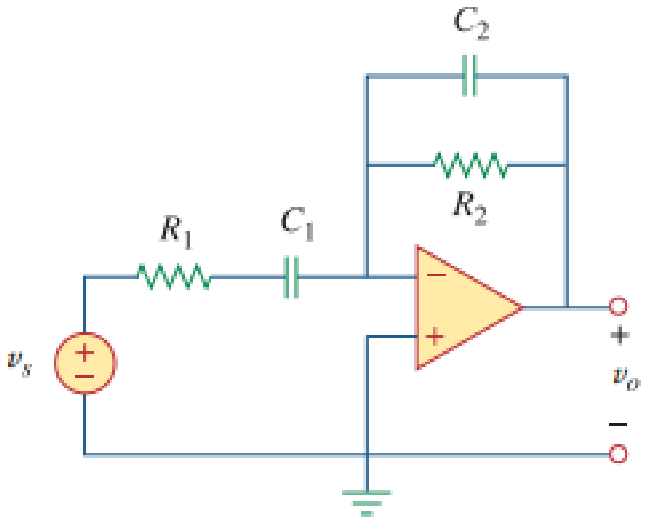
Final Exam – Review

Spring 2018

Problem 1

Compute the closed-loop gain and phase shift for the circuit in Fig. 10.33. Assume that $R_1 = R_2 = 10\ \text{k}\Omega$, $C_1 = 2\ \mu\text{F}$, $C_2 = 1\ \mu\text{F}$, and $\omega = 200$ rad/s.



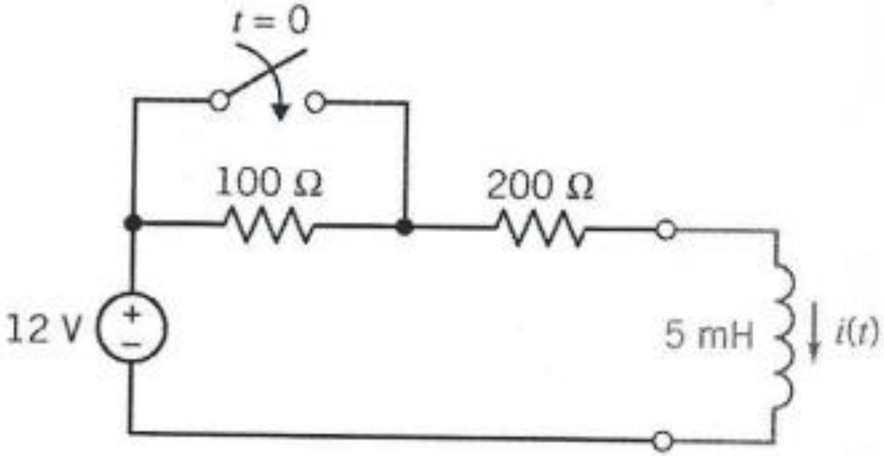
$$\mathbf{Z}_f = R_2 \left\| \frac{1}{j\omega C_2} = \frac{R_2}{1 + j\omega R_2 C_2}\right.$$

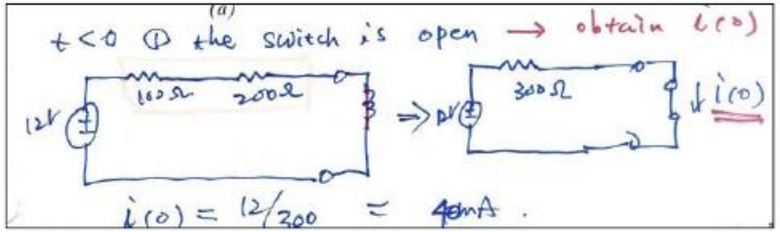
$$\mathbf{Z}_i = R_1 + \frac{1}{j\omega C_1} = \frac{1 + j\omega R_1 C_1}{j\omega C_1}$$

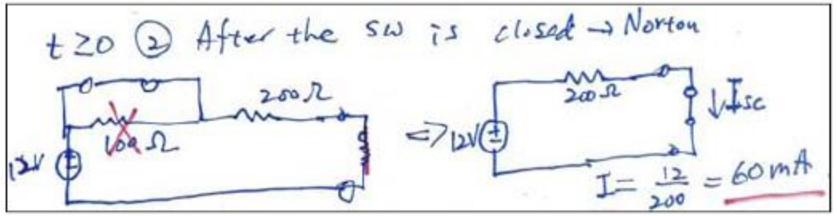
$$\frac{\mathbf{V}_o}{\mathbf{V}_s} = -\frac{\mathbf{Z}_f}{\mathbf{Z}_i} = \frac{-j\omega C_1 R_2}{(1 + j\omega R_1 C_1)(1 + j\omega R_2 C_2)} = \frac{-j4}{(1 + j4)(1 + j2)} = 0.434\underline{/130.6^\circ}$$

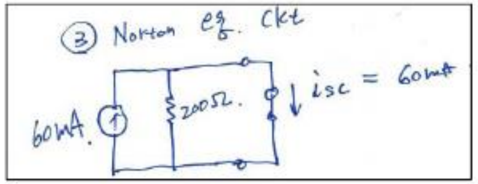
Problem 2

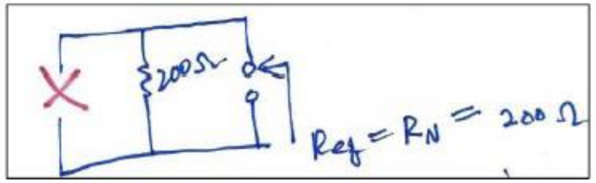
Calculate *i(t)*

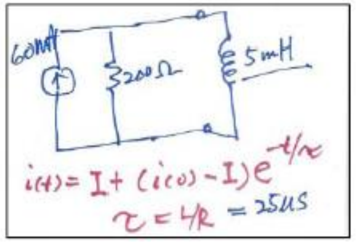








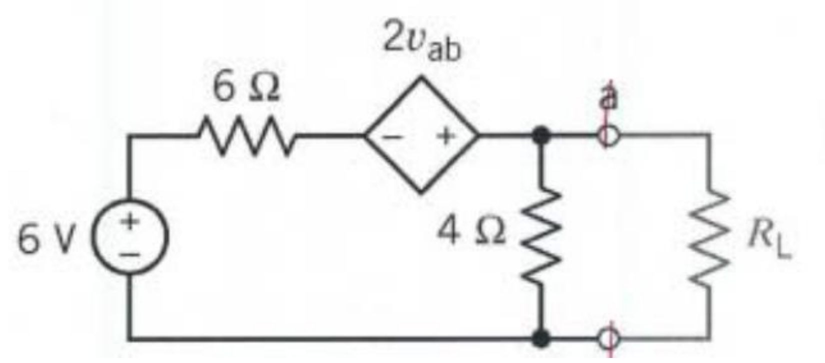


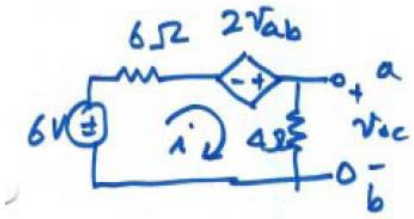


$$i(t) = I + \left(i(0) - I\right)e^{-\frac{t}{\tau}}$$

Problem 3

Find the Thévenin equivalent circuit





KVL for v_{ab}

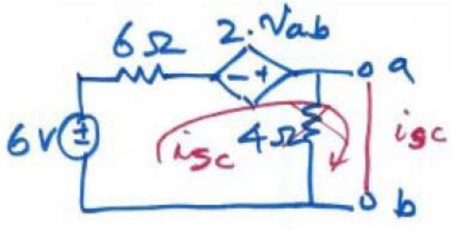
$-6 + 10i - 2v_{ab} = 0.$

$v_{ab} = v_{oc} = 4 \cdot i$

$10i - 8i = 6$

$2i = 6,\ i = 3$

$v_{oc} = i \cdot R = 3 \cdot 4 = 12V.$



KVL for v_{ab}

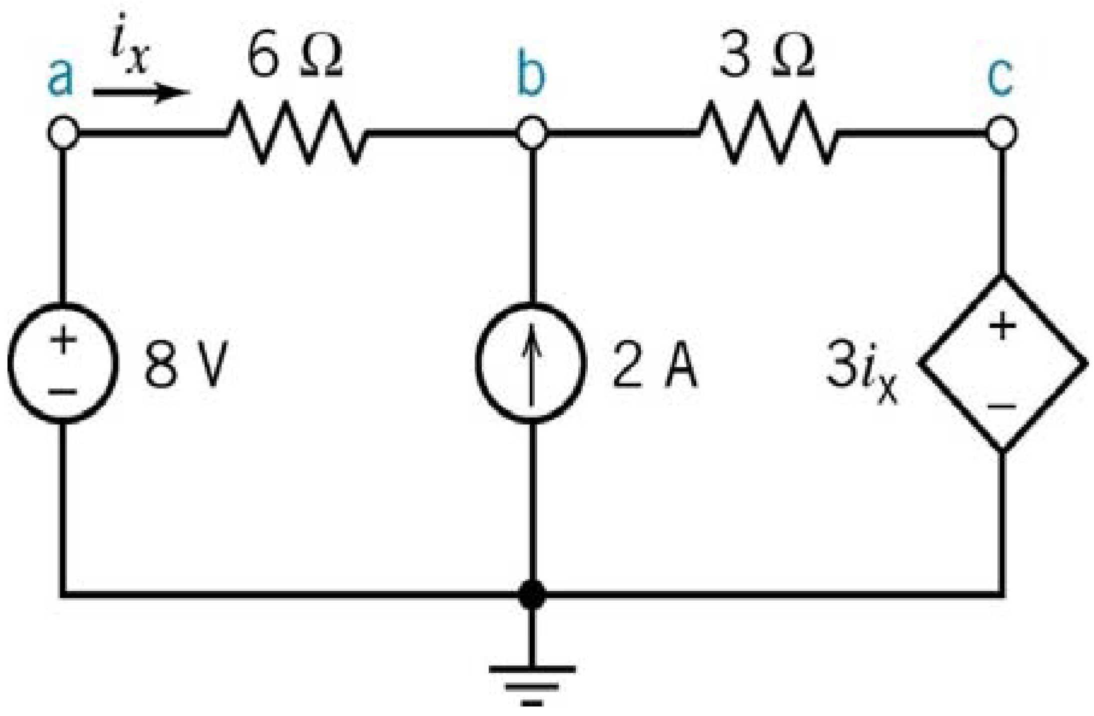
$-6 + 6 \cdot i_{sc} + 0 = 0$

$i_{sc} = 1A$

$$\boxed{R_{eq} = \frac{v_{oc}}{i_{sc}} = \frac{12}{1}}$$

Problem 4

Calculate node voltages



At node a: $i_x = \frac{v_a - v_b}{6}$

$v_a = \boxed{8\ V}$

$$i_x = \frac{8 - v_b}{6}$$

At node c:

$$v_c = 3i_x = 3\frac{(8 - v_b)}{6} = 4 - \frac{v_b}{2}$$

At node b:

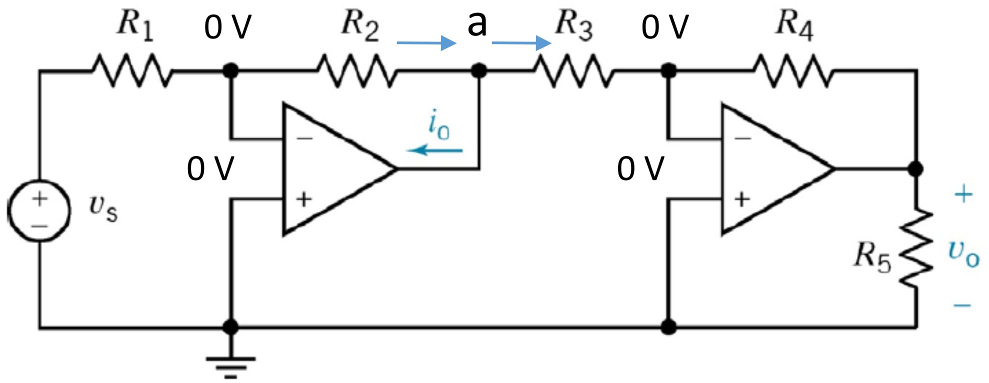
$$\frac{8 - v_b}{6} + 2 - \frac{v_b - v_c}{3} = 0$$

$v_b = \boxed{7\ V}$

$$v_c = 4 - \frac{v_b}{2} = \boxed{\frac{1}{2}\ V}$$

Problem 5

Find i_o and v_o if v_s = 1 V, R_1 = 10 Ω, R_2 = 50 Ω, R_3 = 20 Ω and R_4 = 80 Ω



1st circuit: $\frac{v_{out}}{v_{in}} = -\frac{R_2}{R_1} = -\frac{50}{10} = -5$

2nd circuit: $\frac{v_{out}}{v_{in}} = -\frac{R_4}{R_3} = -\frac{80}{20} = -4$

Gain = $-5 \cdot -4 = 20$

$v_{out} = -5 \cdot -4 \cdot v_s = -5 \cdot -4 \cdot 1V = 20$ V

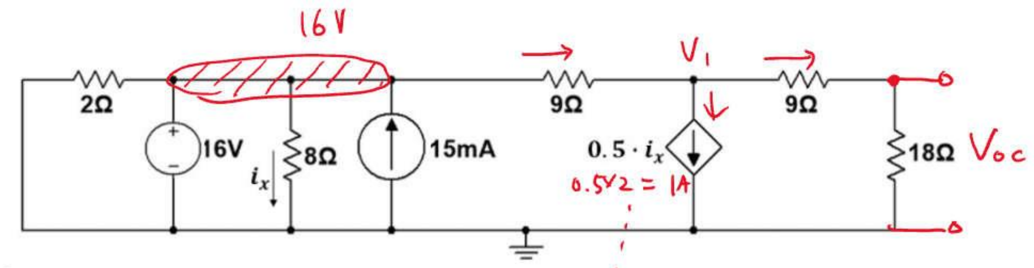
KCL at node a (note that V_a = -5V):

$$\frac{0 - V_a}{R_2} - \frac{V_a - 0}{R_3} = i_0$$

Then solve for $i_0 = 0.35$ A

Problem 6

Obtain the Norton equivalent circuit



$i_x = 16/8 = 2A.$

Node analysis.

@ V_1

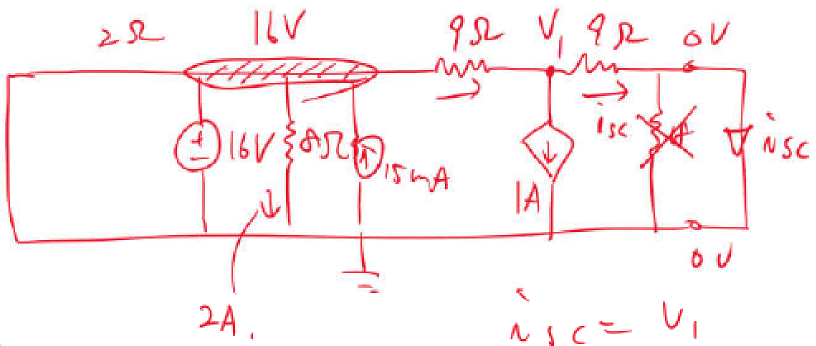
$$\frac{16 - V_1}{9} - 1A - \frac{V_1}{27} = 0 \quad \times 27$$

$$48 - 3V_1 - 27 - V_1 = 0$$

$$-4V_1 + 21 = 0,$$

$$V_1 = 5.25V$$

V. divider $\frac{18}{18+9} \cdot 5.25 = \underline{\underline{3.5\ V}}$.



@ V_1

$$i_{sc} = \frac{V_1}{9}$$

$$\frac{16 - V_1}{9} - 1A - \frac{V_1}{9} = 0$$

$$16 - V_1 - 9 - V_1 = 0$$

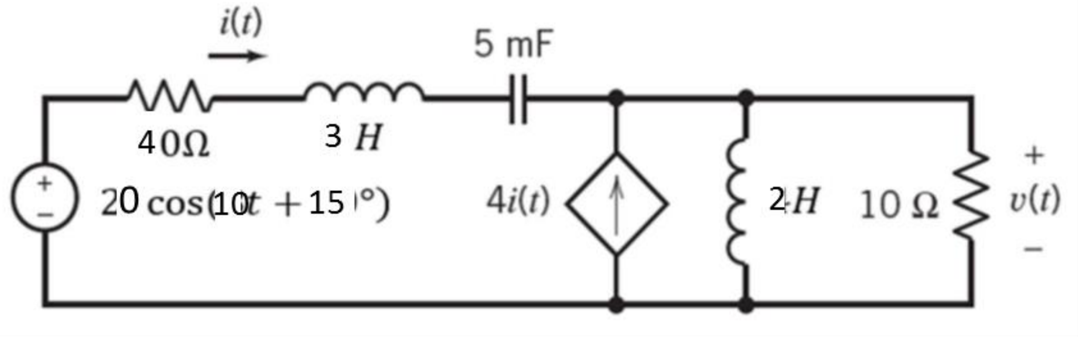
$$-2V_1 + 7 = 0$$

$$V_1 = 3.5\ V.$$

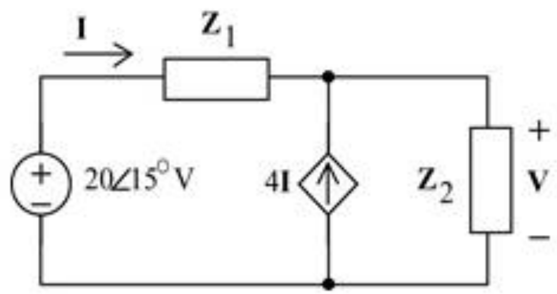
$$i_{sc} = \frac{V}{9} = \frac{3.5}{9} = 0.3888\ A.$$

Problem 7

Determine the steady-state voltage *v(t)* and current *i(t)* for the circuit below



(b) Represent the circuit in the frequency domain using phasors and impedances.



Where $$\mathbf{Z}_1 = 40 + j(10)3 + \frac{1}{j(10)(0.005)} = 40 + j10 = 41.23\angle 26.6° \ \Omega$$

And $$\mathbf{Z}_2 = \frac{j(10)2 \cdot 10}{j(10)2+10} = 8 + j4 = 8.944\angle 26.6° \ \Omega$$

Using KCL and then KVL gives

$$20\angle 15° = \mathbf{Z}_1\mathbf{I} + 5\mathbf{Z}_2\mathbf{I} \quad \Rightarrow \quad \mathbf{I} = 0.234\angle -5.6° \text{ A}$$

Then $$\mathbf{V} = \mathbf{Z}_2(5\mathbf{I}) = 10.47\angle 21° \text{ A}$$

so $$i(t) = 0.234\cos(10t - 5.6°) \text{ A}$$

and $$v(t) = 10.47\cos(10t + 21°) \text{ V}$$