United States Naval Academy
Electrical and Computer Engineering Department
EE 221
Exam 2
02 November 2011

1. You must present your work completely and legibly to receive partial credit. You must show sufficient steps to justify intermediate results as well as final answers.
2. Put all your work on the exam. If you need more space than that provided, ask your instructor for paper. Write your answer clearly and use appropriate units. You have 50 minutes to work this examination.
3. **You are not permitted to discuss the contents of this exam until after 6th period today.**

Page	Value	Score
1	10	
2	15	
3	25	
4	25	
5	25	
Total	100	

Name Solution

I have neither given nor received assistance while completing this exam.

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Signed and Dated

Short Answer Problems: Circle or fill-in the correct choice as appropriate.

(1) (2 points) The voltage across an inductor can change abruptly.(TRUE FALSE) (Circle one)

(2) (2 points) In an AC circuit, the current through an inductor always (LEADS LAGS) the voltage across the inductor. (Circle one)

(3) (2 points) Given a voltage of v(t) = 5sin(1000t + 40°) V across a capacitor, if the amplitude of the current is 2mA, determine i(t) for the capacitor.

$i(t) = 2\sin(1000t + 130°)$ mA

Ok

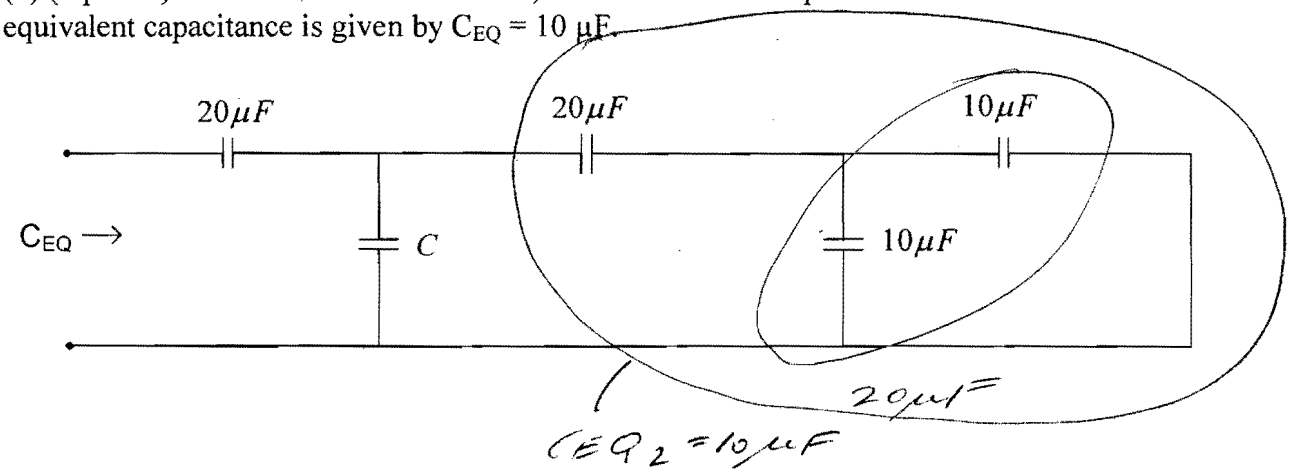
$i(t) = 2\cos(1000t + 40°)$ mA

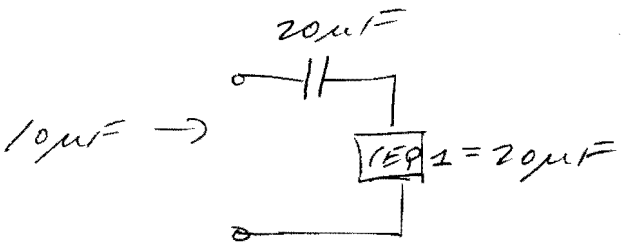
(4) (2 points)As frequency **increases,** an inductor looks more like an(OPEN SHORT). (Circle one)

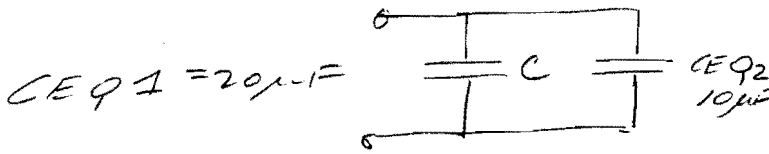
(5) (2 points) How many time constants is a "long" time?

5T is a long time

(6) (5 points) In the circuit shown below, find the value of capacitance C such that the equivalent capacitance is given by C_{EQ} = 10 μF.

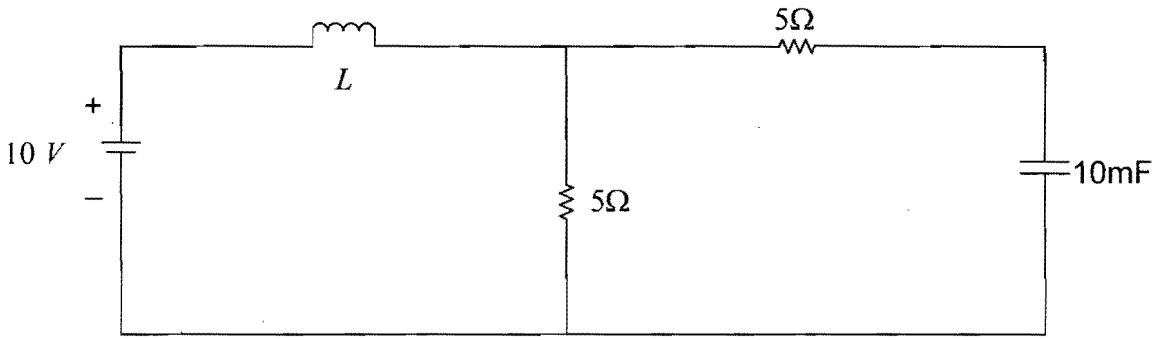


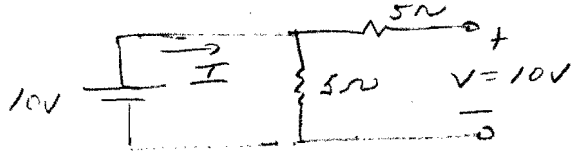




C = 10μF

(7) (10 points) In the circuit shown below, find the value of L such that the total energy stored in the reactive components of the **DC CIRCUIT** is 4J.





$I = \frac{10V}{5\Omega} = 2A$

$W_C = \frac{1}{2} C V^2$

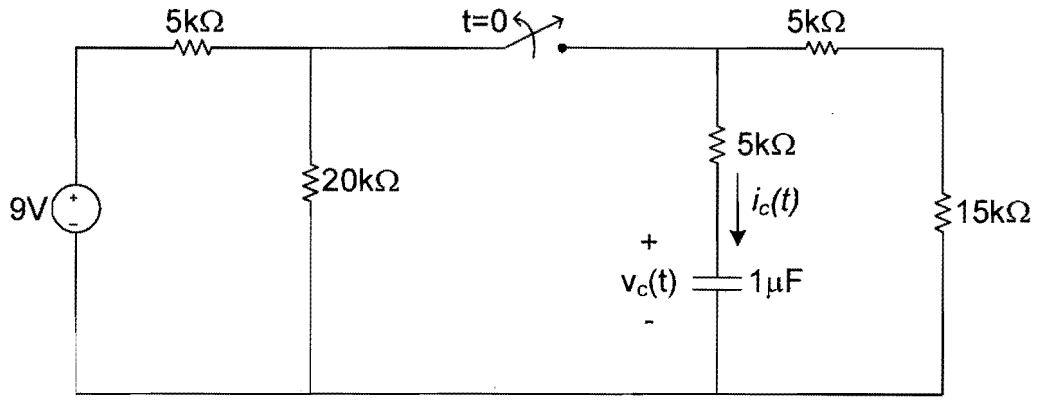
$= \frac{1}{2} (10m)(10^2) = 0.5J$

$W = 4 - W_C = 3.5 = \frac{1}{2} L I^2$

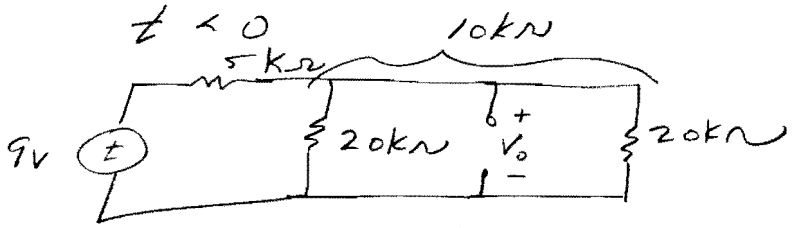
$3.5 = \frac{1}{2} L (2)^2$

$L = 1.75H$

(8) (25 points) In the circuit shown below, the switch **(which has been CLOSED for a long time)** opens at t = 0. Find $v_c(t)$ and $i_c(t)$ for the capacitor **for time t > 0.**

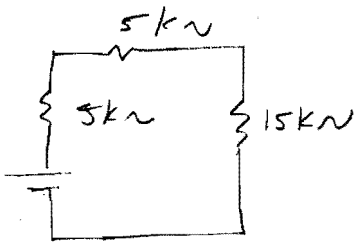


$t < 0$



$$V_o = \left(\frac{10k}{5k+10k}\right) 9 = 6V$$

$t > 0$



$V_\infty = 0V$

$R_{Th} = 25k\Omega$

$\tau = RC$

$= (25k)(1\mu) = 25 msec$

$$v_c(t) = V_\infty + (V_0 - V_\infty) e^{-t/\tau}$$

$$= 0 + (6 - 0) e^{-40t}$$

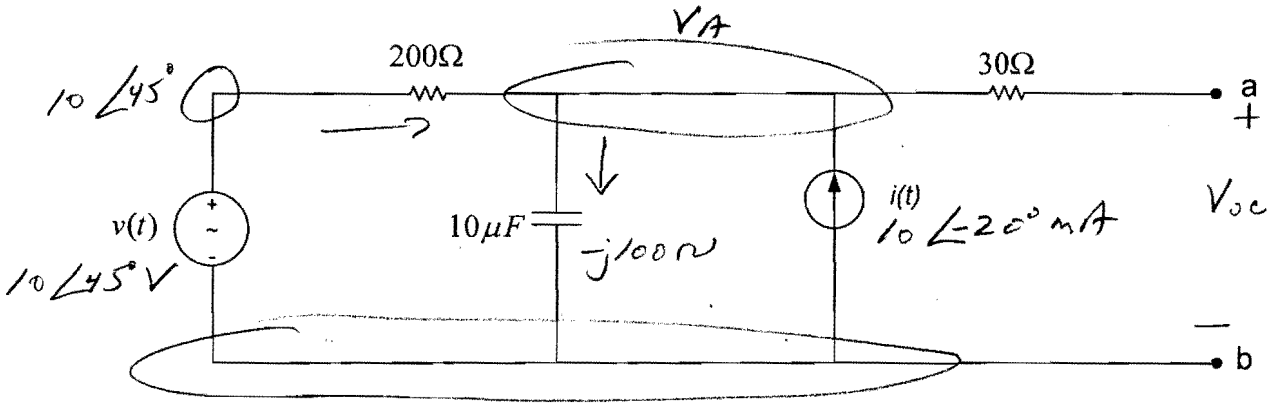
$$= 6 e^{-40t} \; V$$

$$i_c(t) = C \frac{dv}{dt}$$

$$= (1\mu)\, 6\, (-40)\, e^{-40t}$$

$$= -240\, e^{-40t} \; \mu A$$

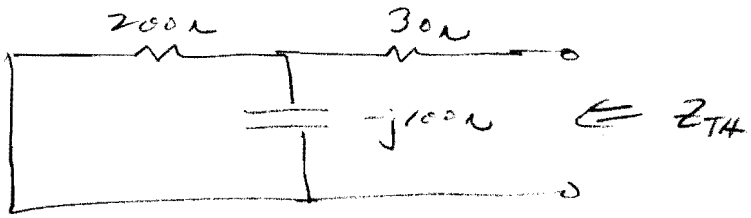
(9) (25 points) For the circuit shown below given v(t) = 10 cos(1000t +45°)V and i(t) = 10 cos(1000t -20°) mA find and **DRAW** the Thevenin equivalent circuit at the terminals 'a-b', expressing phasors in **polar** form and impedances in **rectangular** form.



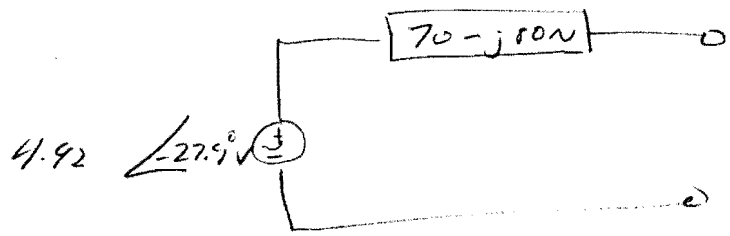
$$Z_C = -j\left(\frac{1}{\omega C}\right) = -j\,\frac{1}{(1k)(10\mu)} = -j100\,\Omega$$

$$\frac{10\angle 45^\circ - V_A}{200} + 10m\angle -20^\circ = \frac{V_A}{-j100}$$

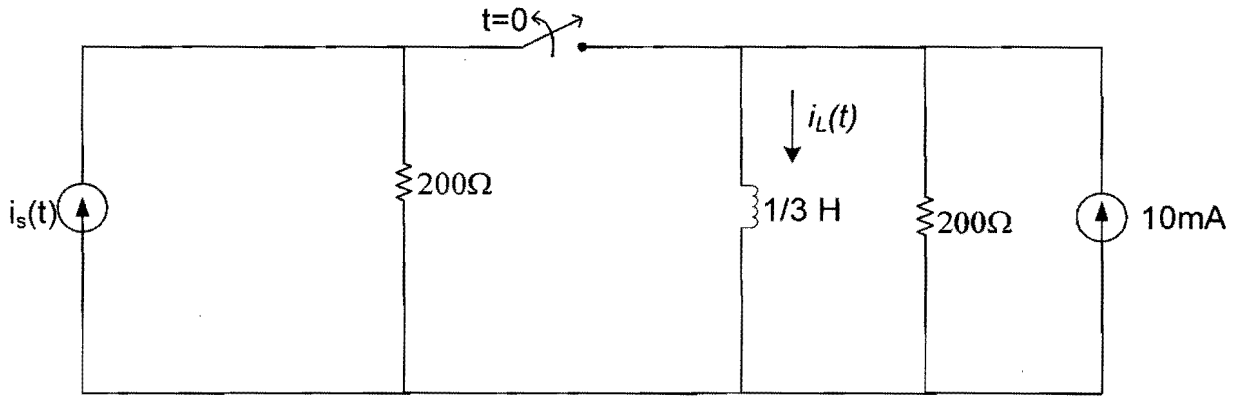
$$V_{TH} = V_A = 4.92\angle -27.9^\circ\ V$$



$$Z_{TH} = (200\ //\ -j100) + 30 = 70 - j80\,\Omega$$



(10) (25 points) In the circuit shown below, $i_s(t) = 20\cos(300t)$ mA. The switch **which has been closed for a LONG TIME** opens at t = 0.

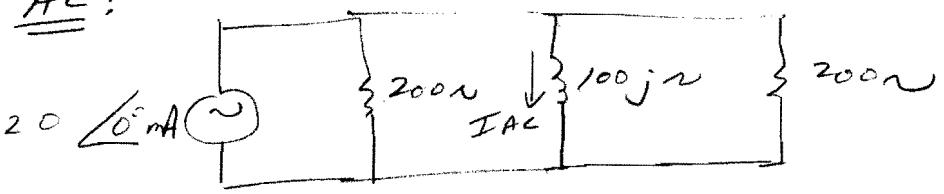


(a) (10 points) Solve for the current through the inductor, $i_L(t)$ for t < 0. (Hint:Use AC superposition)

$t < 0$

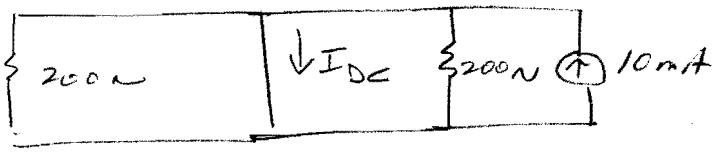
$Z_L = j\omega L = j(300)(1/3) = 100j\ \Omega$

AC:



$$I_{AC} = \left(\frac{100}{100+j100}\right) 20m\angle 0° = 14.14\angle -45°\ mA$$

DC:



$$I_{DC} = 10\ mA$$

$$i(t) = 10\ mA + 14.14\cos(300t - 45°)\ mA$$

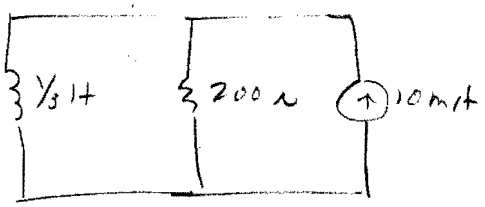
(b) (5 points) What is the **numerical** value of the inductor current at t = 0, $i_L(0)$?

$$i(0) = 10\,mA + 14.14 \cos(300(0) - 45^\circ)$$
$$= 10\,mA + 14.14 \cos(-45^\circ)$$
$$= 10\,mA + 10\,mA = 20\,mA$$

(c) (10 points) Solve for the inductor current $i_L(t)$ for t > 0. (Hint: This is the step response)

$t > 0$, $i(0) = 20\,mA$

$$i(t) = I_\infty + (I_0 + I_\infty) e^{-t/\tau}$$



$I_\infty = 10\,mA$

$$\tau = L/R = \frac{1/3\,H}{200} = 1.67\,ms$$

$$i(t) = 10\,mA + (20\,mA - 10\,mA) e^{-600t}$$
$$= 10\,mA + 10\,mA\, e^{-600t}$$