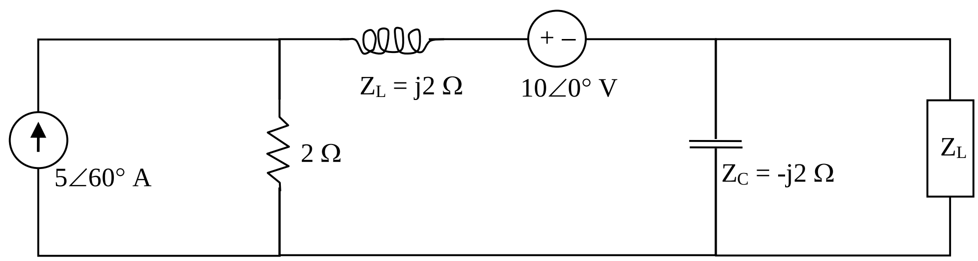
EECS 70B
Some examples of problems for the Preliminary Examination in EE-Circuits & Devices

Note that these are just some examples. Completely different problems may be given.

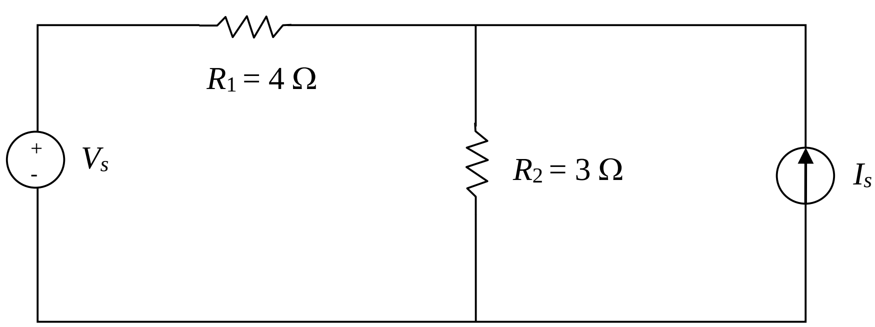
Problem

Determine the load impedance Z_L for maximum average power transfer.



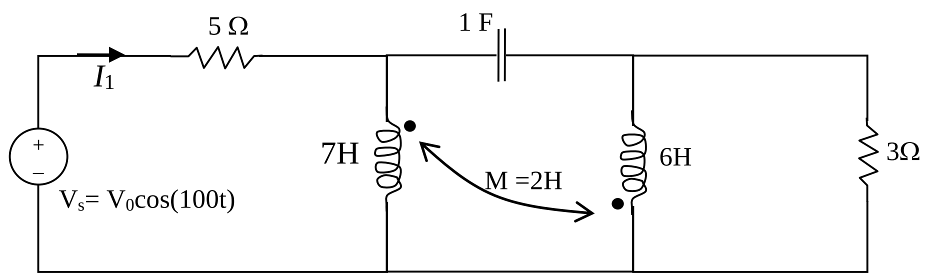
Problem

Determine the complex power delivered or absorbed by EACH source, and the one delivered to each resistor. Assume that $V_s = 16\angle 30°[V]$ and $I_s = 2\angle(-90°)[A]$. (Note that 16V and 2 A, are the maximum values of the voltage and current generators, not the rms values)



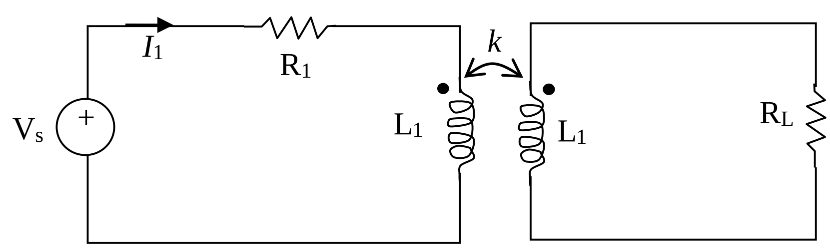
Problem

Write a complete set of phasor mesh equations for the circuit in the figure below. You do not need to solve it completely, but you need to write a complete and reduced (simple) set of equations (N equation in N unknowns) that would lead to the solution (i.e., determination of all voltages and currents) once solved. The mutual coupling M between the two inductors is 2H.



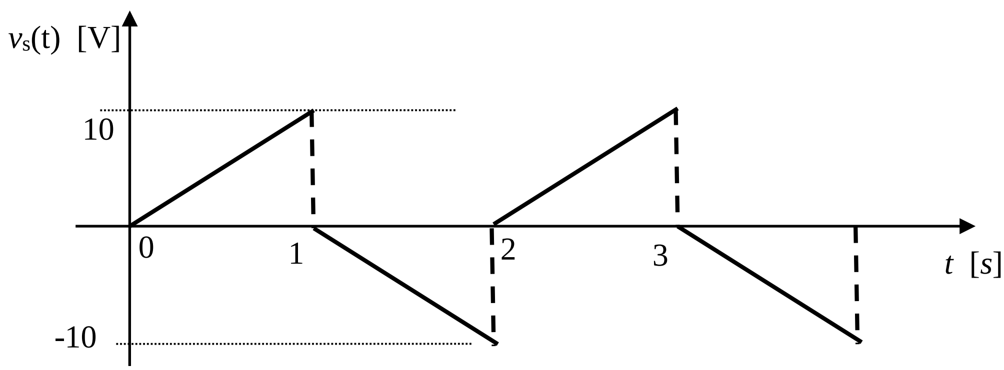
Problem

Derive the expression of the impedance seen by the voltage generator. Derive the expression of the current I_1 (sign errors will count significantly. Note this is not an "ideal" transformer).



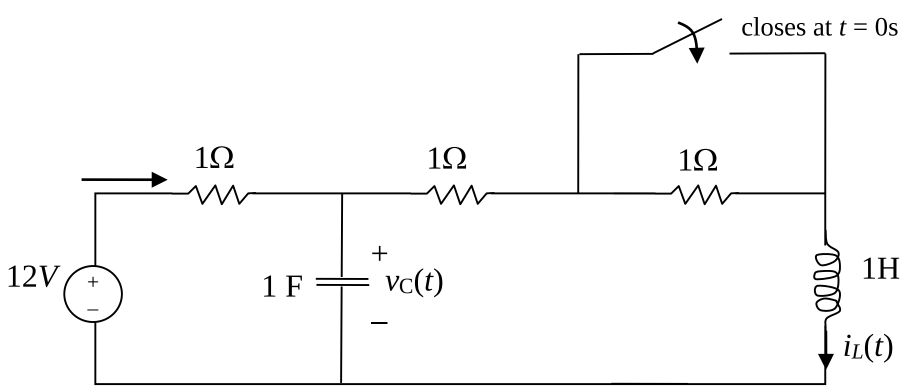
Problem

Derive the rms value of the periodic voltage waveform shown in the figure



Problem

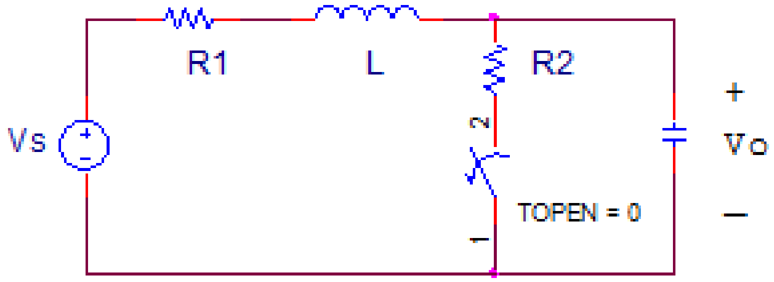
Consider the circuit shown in the figure below. Using the Laplace transform technique determine the current in the inductor, $i_L(t)$, for t > 0. (Be careful to the initial conditions.)



Laplace transform table you may want to use

$f(t)$ **(t >0-)**	$F(s)$	$f(t)$	$F(s)$
$\delta(t)$	1	$\frac{df(t)}{dt}$	$sF(s)-f(0^-)$
$\delta'(t)$	s	$\frac{d^2f(t)}{dt^2}$	$s^2F(s)-sf(0^-)-\frac{df(0^-)}{dt}$
$u(t)$	$\frac{1}{s}$	$\int_0^1 f(t)\,dt$	$\frac{F(s)}{s}$
t	$\frac{1}{s^2}$	$f(t-a)u(t-a)$	$e^{-as}F(s)$
e^{-at}	$\frac{1}{s+a}$	$e^{-at}f(t)$	$F(s+a)$
$\sin\omega t$	$\frac{\omega}{s^2+\omega^2}$	$f(at),\quad a>0$	$\frac{1}{a}F\left(\frac{s}{a}\right)$
$\cos\omega t$	$\frac{s}{s^2+\omega^2}$	$tf(t)$	$-\frac{dF(s)}{ds}$
te^{-at}	$\frac{1}{(s+a)^2}$	$t^n f(t)$	$(-1)^n\frac{d^nF(s)}{ds^n}$
$e^{-at}\sin\omega t$	$\frac{\omega}{(s+a)^2+\omega^2}$	$\frac{f(t)}{t}$	$\int_s^\infty F(u)\,du$
$e^{-at}\cos\omega t$	$\frac{(s+a)}{(s+a)^2+\omega^2}$		
$2\lvert K\rvert e^{-at}\cos(\omega t+\theta)$, $K=\lvert K\rvert e^{j\theta}$	$\frac{K}{s+\alpha-j\beta}+\frac{K^*}{s+\alpha+j\beta}$		

1. (70 pts) The switch of the following LCR circuit has been closed for a long time. It is opened at t = 0.
(a) Solve vo(t) for t > 0 using the differential equation method. (30 pts)
(b) Solve vo(t) for t > 0 using the Laplace Transform method. (30 pts)
(c) Identify the natural response and forced response for your answer in (b) and (c). (10 pts)
(Vs=12V, C = 0.4F, R1 = 4Ω, L = 0.25H and R2 =2Ω)



2. (30 pts) Sketch the Bode Magnitude plot for $H(\omega) = \frac{-5000(j\omega)}{(20+j\omega)(200+j\omega)}$

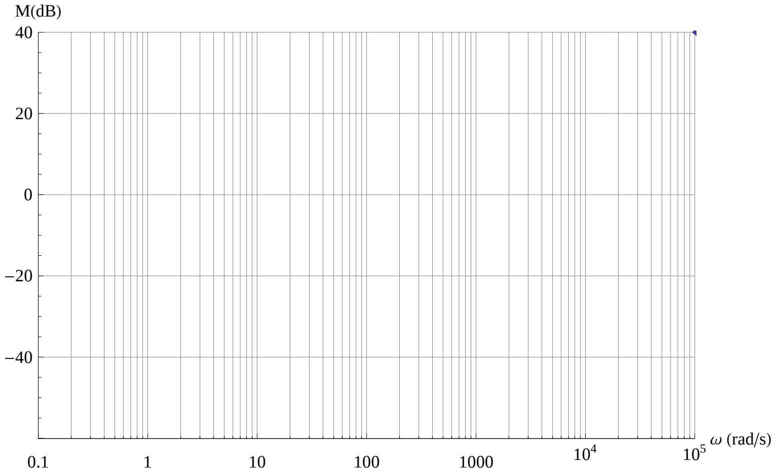

M(dB)
40
20
0
−20
−40
0.1
1
10
100
1000
10^4
10^5
ω (rad/s)

TABLE 15.1 Properties of the Laplace transform.

Property	$f(t)$	$F(s)$
Linearity	$a_1 f_1(t) + a_2 f_2(t)$	$a_1 F_1(s) + a_2 F_2(s)$
Scaling	$f(at)$	$\frac{1}{a} F\left(\frac{s}{a}\right)$
Time shift	$f(t-a)u(t-a)$	$e^{-as} F(s)$
Frequency shift	$e^{-at} f(t)$	$F(s+a)$
Time differentiation	$\frac{df}{dt}$	$sF(s) - f(0^-)$
	$\frac{d^2f}{dt^2}$	$s^2F(s) - sf(0^-) - f'(0^-)$
	$\frac{d^3f}{dt^3}$	$s^3F(s) - s^2 f(0^-) - sf'(0^-) - f''(0^-)$
	$\frac{d^nf}{dt^n}$	$s^nF(s) - s^{n-1} f(0^-) - s^{n-2} f'(0^-) - \cdots - f^{(n-1)}(0^-)$
Time integration	$\int_0^t f(t)\,dt$	$\frac{1}{s} F(s)$
Frequency differentiation	$tf(t)$	$-\frac{d}{ds} F(s)$
Frequency integration	$\frac{f(t)}{t}$	$\int_s^\infty F(s)\,ds$
Time periodicity	$f(t) = f(t + nT)$	$\frac{F_1(s)}{1 - e^{-sT}}$
Initial value	$f(0)$	$\lim_{s\to\infty} sF(s)$
Final value	$f(\infty)$	$\lim_{s\to 0} sF(s)$
Convolution	$f_1(t) * f_2(t)$	$F_1(s)F_2(s)$

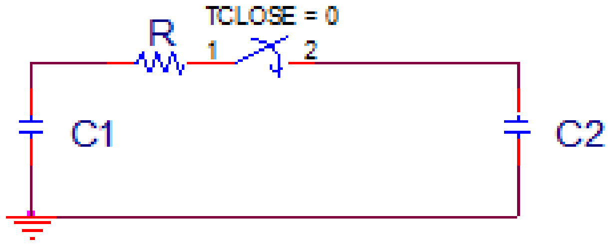
TABLE 15.2

Laplace transform pairs.*

$f(t)$	$F(s)$
$\delta(t)$	1
$u(t)$	$\frac{1}{s}$
e^{-at}	$\frac{1}{s+a}$
t	$\frac{1}{s^2}$
t^n	$\frac{n!}{s^{n+1}}$
te^{-at}	$\frac{1}{(s+a)^2}$
$t^n e^{-at}$	$\frac{n!}{(s+a)^{n+1}}$
$\sin \omega t$	$\frac{\omega}{s^2 + \omega^2}$
$\cos \omega t$	$\frac{s}{s^2 + \omega^2}$
$\sin(\omega t + \theta)$	$\frac{s \sin\theta + \omega \cos\theta}{s^2 + \omega^2}$
$\cos(\omega t + \theta)$	$\frac{s \cos\theta - \omega \sin\theta}{s^2 + \omega^2}$
$e^{-at} \sin \omega t$	$\frac{\omega}{(s+a)^2 + \omega^2}$
$e^{-at} \cos \omega t$	$\frac{s+a}{(s+a)^2 + \omega^2}$

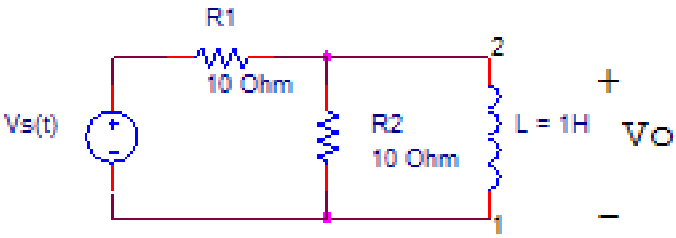
*Defined for $t \geq 0$; $f(t) = 0$, for $t < 0$.

1. (50 pts) Consider the circuit below with the following parameters and initial conditions: C1 = 10 nF, C2 = 1nF, R = 10kΩ and Vc1(t = 0) = 0 Volt, Vc2(t = 0) = 5 Volt. At t=0, the switch is closed.



(a) Calculate the final values for Vc1 and Vc2, the voltage across each capacitor. (15 pts)
(b) Calculate total energy lost in the circuit between t = 0 and t = ∞ by considering change of stored energy in the capacitors (10 pts)
(c) Calculate total energy lost in the circuit between t = 0 and t = ∞ by considering power dissipated in the resistor. (to do this, you
have to solve for the waveform i(t) for t > 0) (25 pts)

2. (50 pts) Consider the following circuit :



(a) For vs(t) = 10 $e^{-t}u(t)$, start with the differential equation in terms of iL(t), proceed to solve for vo(t) for t > 0 with initial condition iL(0-) = 0.5 A. (iL(t) is defined as a current flowing from terminal 2 to 1 on the inductor). Label the solution due to homogeneous differential equation and the particular solution separately. (15 pts)

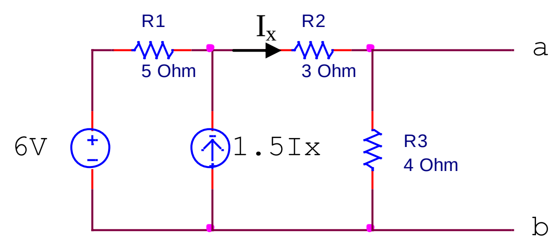
(b) Repeat (a) using the Laplace Transform Method. Label the zero-state and zero-input responses separately. (10pts)

(c) If vs(t) is replaced by 10Cos(2t)u(t), find the steady-state vo(t) using the phasor method (10pts).

(d) Repeat part(c) using Laplace Transform method and show that your result in (c) is identical to that of (d) (15 pts).

Prelim Exam on Circuits (70B)

1. Find the Thevenin equivalent circuit at terminals a-b. (note that the current source is a dependent one)



2. Find the complete response of v(t) for the following circuit for t > 0. The switch is closed at t=0.