Department of Electrical & Computer Engineering
University of California, Santa Barbara

Homework #7

Due Date: June 6, 2008 (by 5:00 pm)

Problem 1

The circuit shown in Fig. has been in operation for a long time. At $t = 0$, the voltage suddenly increases to 250 V. Find $v_o(t)$ for $t \geq 0$.

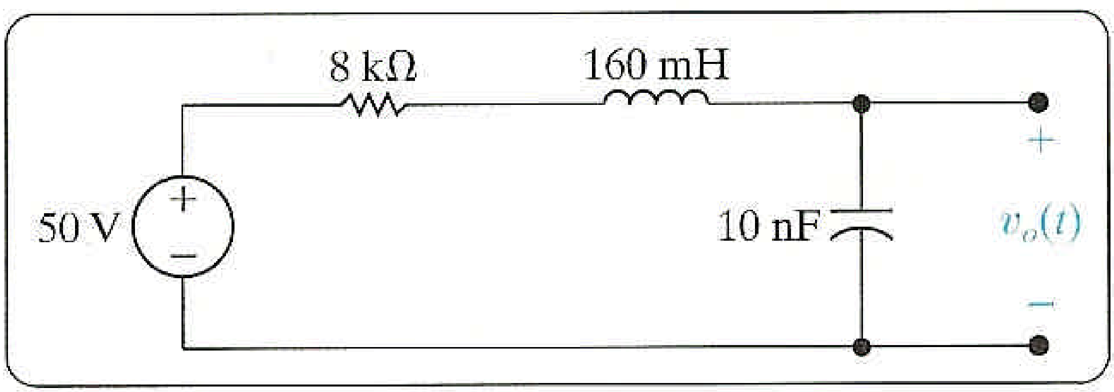

Fig. For Problem 1

Problem 2

Assume that the capacitor voltage in the circuit of Fig. is underdamped. Also assume that no energy is stored in the circuit elements when the switch is closed.

a) Show that $dv_C/dt = (\omega_0^2/\omega_d)Ve^{-\alpha t}\sin\omega_d t$.

b) Show that $dv_C/dt = 0$ when $t = n\pi/\omega_d$, where $n = 0, 1, 2, \ldots$.

c) Let $t_n = n\pi/\omega_d$, and show that $v_C(t_n) = V - V(-1)^n e^{-\alpha n\pi/\omega_d}$.

d) Show that

$$\alpha = \frac{1}{T_d} \ln \frac{v_C(t_1) - V}{v_C(t_3) - V},$$

where $T_d = t_3 - t_1$.

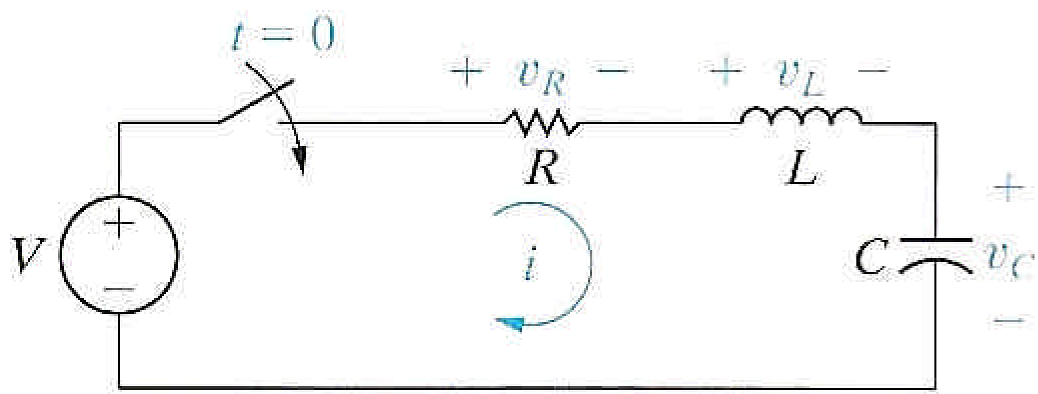

Fig. For Problem 2

Problem 3

The voltage signal of Fig. (a) is applied to the cascaded integrating amplifiers shown in Fig. (b). There is no energy stored in the capacitors at the instant the signal is applied.

a) Derive the numerical expressions for $v_o(t)$ and $v_{o1}(t)$ for the time intervals $0 \le t \le 0.5$ s and $0.5 \text{ s} \le t \le t_{sat}$.

b) Compute the value of t_{sat}.

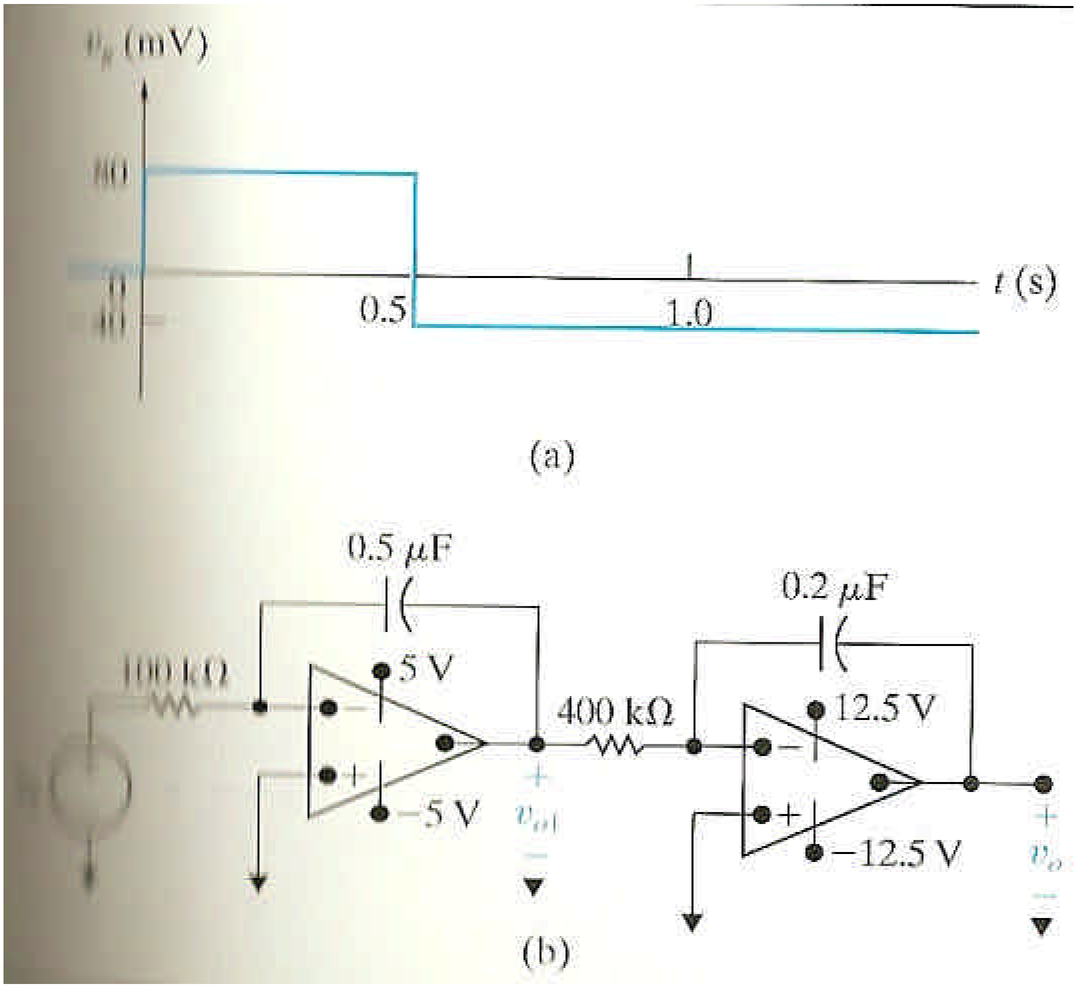

Fig. For Problem 3

Problem 4

We now wish to illustrate how several op amp circuits can be interconnected to solve a differential equation.

a) Derive the differential equation for the spring-mass system shown in Fig. (a). Assume that the force exerted by the spring is directly proportional to the spring displacement, that the mass is constant, and that the frictional force is directly proportional to the velocity of the moving mass.

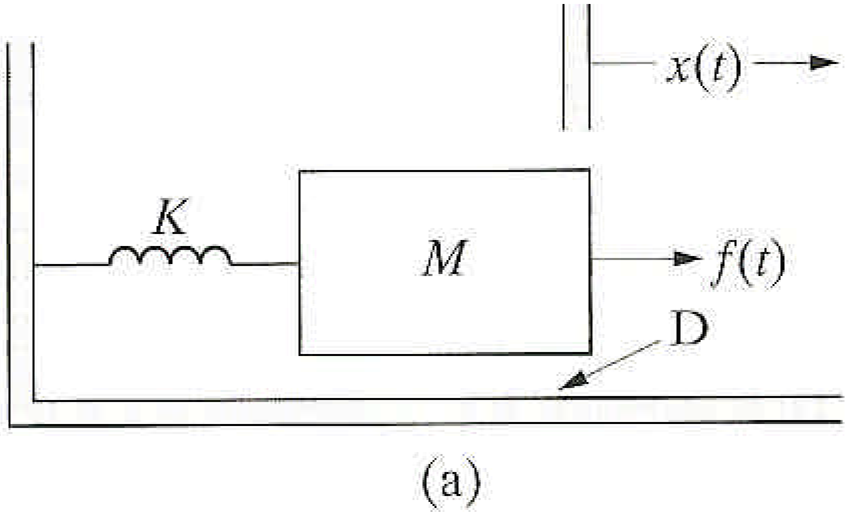

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Fig. For Problem 4

b) Rewrite the differential equation derived in (a) so that the highest order derivative is expressed as a function of all the other terms in the equation. Now assume that a voltage equal to d^2x/dt^2 is available and by successive integrations generates dx/dt and x. We can synthesize the coefficients in the equations by scaling amplifiers, and we can combine the terms required to generate d^2x/dt^2 by using a summing amplifier. With these ideas in mind, analyze the interconnection

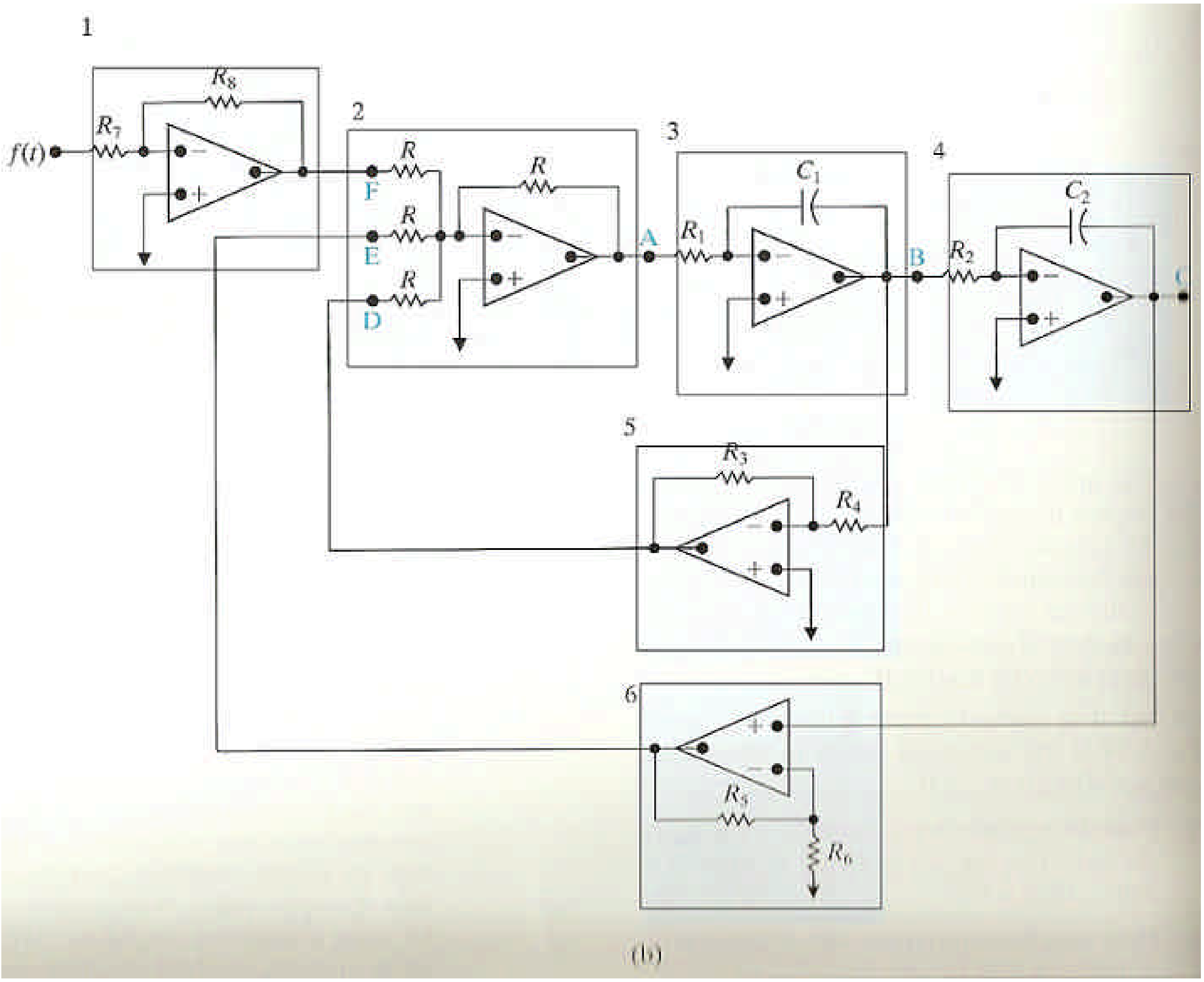

Fig. For Problem 4

Problem 5

A 50 kHz sinusoidal voltage has zero phase angle and a maximum amplitude of 10 mV. When this voltage is applied across the terminals of a capacitor, the resulting steady-state current has a maximum amplitude of 628.32 μA.

a) What is the frequency of the current in radians per second?

b) What is the phase angle of the current?

c) What is the capacitive reactance of the capacitor?

d) What is the capacitance of the capacitor in microfarads?

e) What is the impedance of the capacitor?

Problem 6

The expressions for the steady-state voltage and current at the terminals of the circuit seen in Fig. are

$$v_g = 300\cos(5000\pi t + 78^\circ)\ \text{V},$$

$$i_g = 6\sin(5000\pi t + 123^\circ)\ \text{A}$$

a) What is the impedance seen by the source?

b) By how many microseconds is the current out of phase with the voltage?

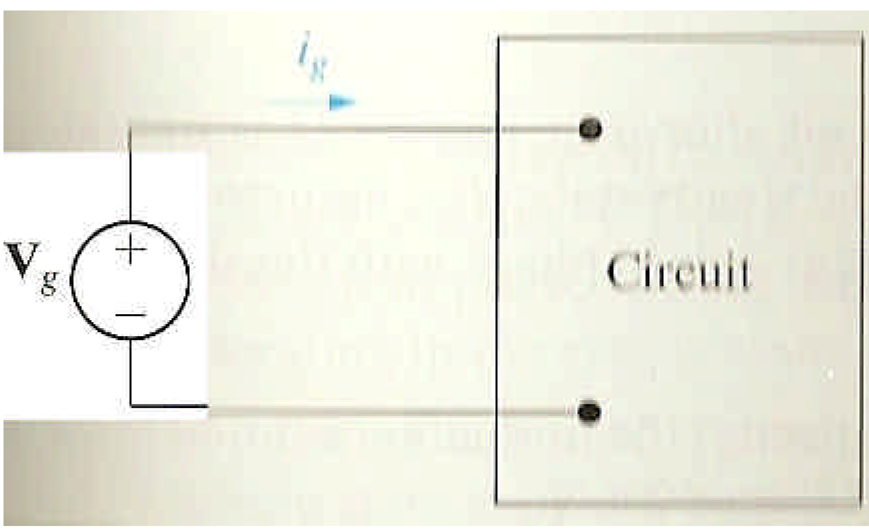

Fig. For Problem 6

Problem 7

Find the impedance Z_{ab} in the circuit seen in Fig. Express Z_{ab} in both polar and rectangular form.

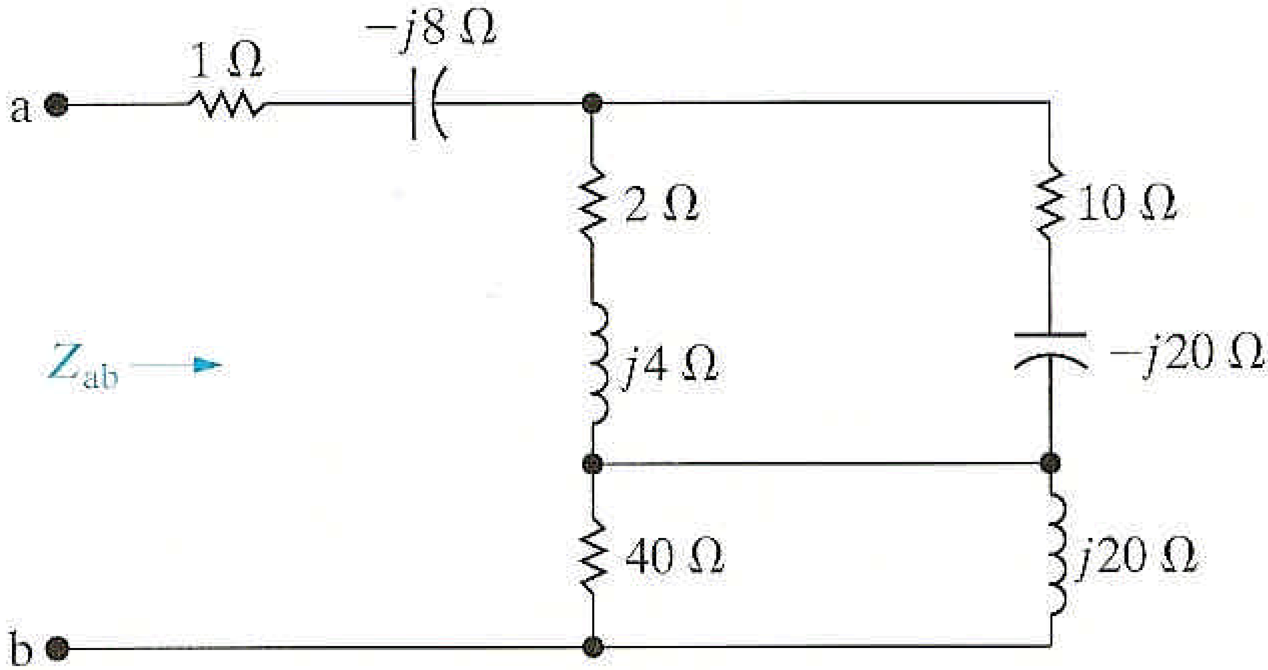

Fig. for Problem 7

Problem 8

The sinusoidal voltage source in the circuit in Fig. is developing a voltage equal to $247.49 \cos(1000t + 45°)$ V.

a) Find the Thévenin voltage with respect to the terminals a,b.

b) Find the Thévenin impedance with respect to the terminals a,b.

c) Draw the Thévenin equivalent.

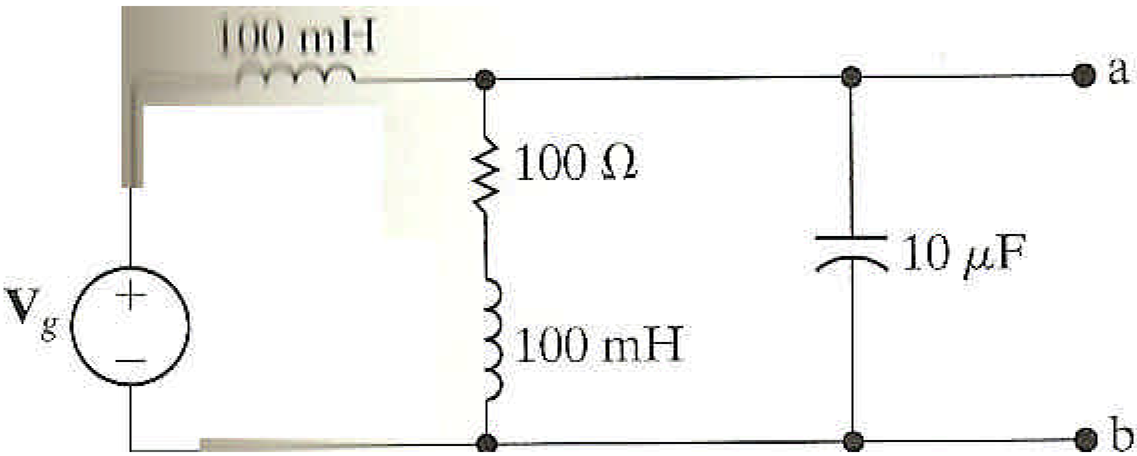

Fig. for Problem 8

Problem 9

Find the value of Z in the circuit seen in Fig. if $\mathbf{V}_g = 100 - j50$ V, $\mathbf{I}_g = 30 + j20$ A, and $\mathbf{V}_b = 140 + j30$ V.

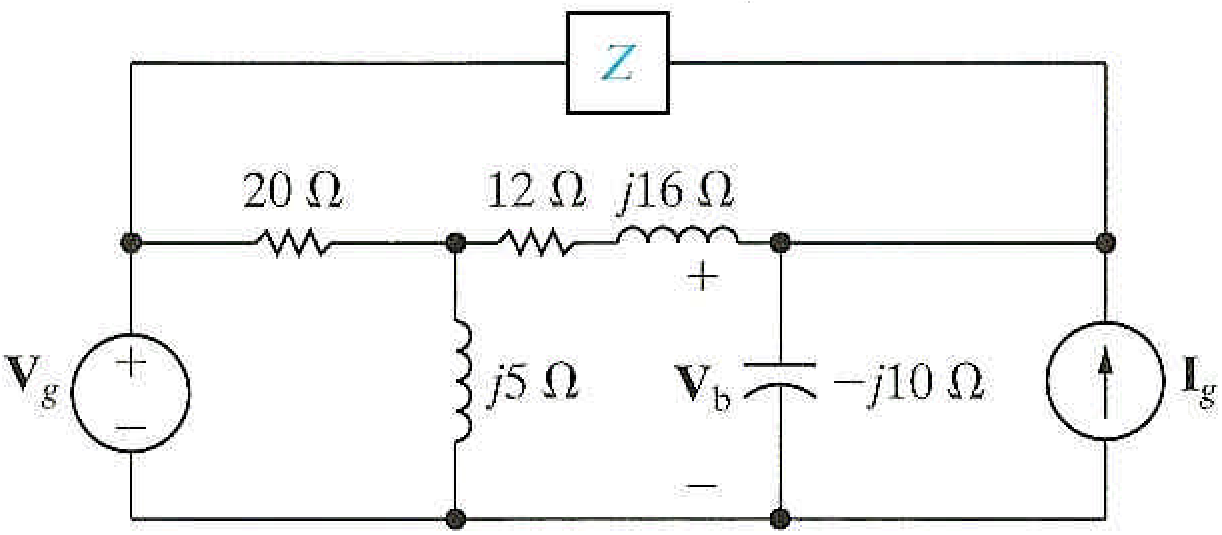

Fig. for Problem 9

End of the Last Homework!!