sheet #4

4.12 For the RC network shown in Figure P4.12(a),

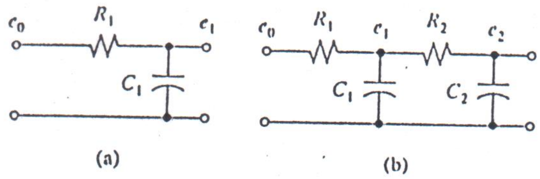


Figure P4.12 (a) RC circuit. (b) Dual RC circuit.

a. *Write* the modeling equations.
b. *Derive* the differential equation of the form $[\tau D + 1]e_1 = Ge_0$.
c. *What* are the mathematical expressions for the time constant τ and the gain G?

Suppose two RC networks are lumped together as shown in Figure P4.12(b).

a. *Write* the modeling equations.
b. *Derive* the differential equation for the circuit.
c. You might be tempted to think that the differential equation for this circuit is simply the product of two RC's. *Prove* that it is not by asking whether

$$(\tau_1 D + 1)(\tau_2 D + 1)e_2 = e_0?$$

4.13 Shown in Figure P4.13 is an electric circuit.

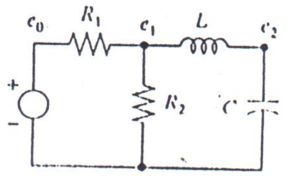


Figure P4.13 RLC circuit.

a. *Write* the modeling equations.
b. *Derive* the differential equation for e_2 as a function of e_0.
c. *State* the initial conditions necessary for the differential equation.
d. *State* the natural frequency, the damping ratio, and the static gain of the circuit.

4.14 For the circuit shown in Figure P4.14, *write* all of the modeling equations and *derive* the transfer function e_2/e_0. All initial conditions are zero.

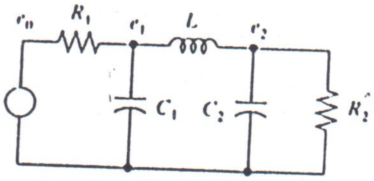


Figure P4.14 RLC circuit.

4.16 For the circuit shown in Figure P4.16, *write* the modeling equations and *derive* the transfer function for e_3 as a function of e_0. *What* is the static gain?

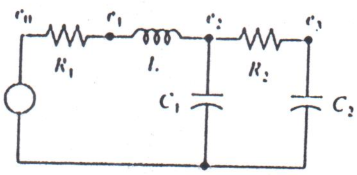


Figure P4.16 RLC circuit.

4.18 Shown in Figure P4.18 is an RLC circuit with a parallel bypass resistor. *Write* the modeling equations and *derive* a differential equation for e_1 as a function of e_0. *Express* the required initial conditions of this second-order differential equation in terms of the known initial conditions $e_1(0)$ and $i_L(0)$.

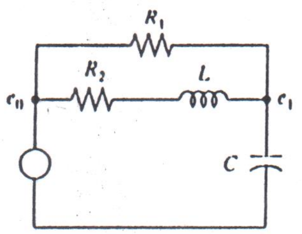


Figure P4.18 RLC circuit.

4.25 Shown in Figure P4.25 is an electronic circuit with an op-amp buffer. *Derive* the differential equation for e_o as a function of the input e_i. *Calculate* the static gain, natural frequency, and damping ratio if $R_f = 10\ k\Omega$, $R_i = 10\ k\Omega$, $C_f = 1\ \mu f$, $R_L = 500\ \Omega$, and $C_L = 10\ \mu f$.

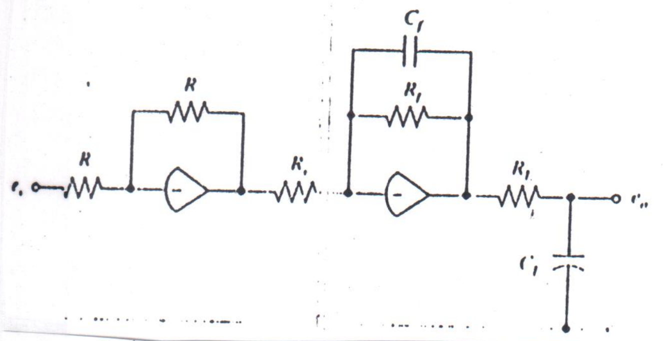


Figure P4.25 Op-amp filter circuit.

4.27 Shown in Figure P4.27 is an op-amp circuit with two capacitors. *Write* the modeling equations and *derive* the transfer function for e_o as a function of e_i

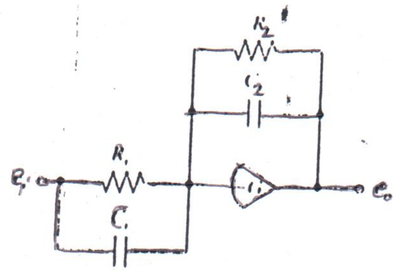
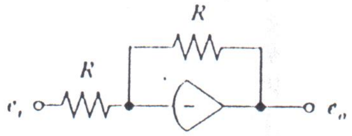
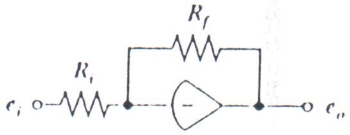
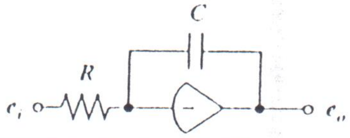
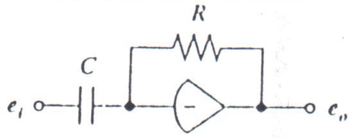
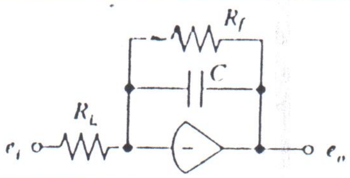
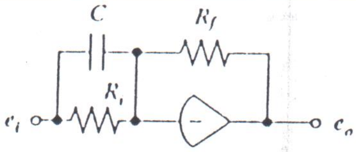
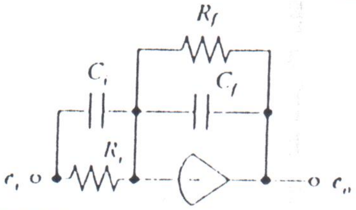
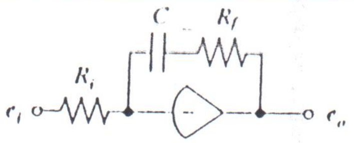


Figure P4.27 Op-amp filter circuit.

Description	Transfer Function	Circuit
Sign Changer	$e_o = -e_i$	
Amplifier	$e_o = -\frac{R_f}{R_i} e_i$	
Integrator	$e_o = \frac{-e_i}{\tau D}$ $\tau = RC$	
Differentiator	$e_o = -\tau D e_i$ $\tau = RC$	
Lag	$e_o = \frac{-\frac{R_f}{R_i} e_i}{(\tau D + 1)}$ $\tau = R_f C$	
Lead	$e_o = -\frac{R_f}{R_i}(\tau D + 1)$ $\tau = R_i C$	
Lead-Lag or Lag-Lead	$e_o = -\frac{R_f}{R_i}\frac{(\tau_i D + 1)e_i}{(\tau_f D + 1)}$ $\tau_i = R_i C_i$ $\tau_f = R_f C_f$	
Bandwidth-Limited Integrator	$e_o = \frac{-(\tau_f D + 1)e_i}{\tau_i D}$ $\tau_f = R_f C$ $\tau_i = R_i C$	
Bandwidth-Limited Differentiator	$e_o = \frac{-\tau_f D e_i}{(\tau_i D + 1)}$ $\tau_f = R_f C$ $\tau_i = R_i C$