1. (10%) (a) Describe Kirchhoff’s Current Law (KCL) (4%). (b) What kind of conservation is the KCL based on? (2%) (c) Can the KCL be applied to (1) linear circuits (1%), (2) nonlinear circuits (1%), (3) time-varying circuits (1%), and (4) non-planar circuits (1%)? Just answer yes or no for the four questions in (c).

2. (12%) (a) Replace the network to the right of terminals a and b in the circuit below by an equivalent resistance, inductance, and capacitance (6%). (b) Suppose a voltage source of 1V is connected to the circuit between terminals a and b, please find the corresponding current for the equivalent resistance, inductance, and capacitance, respectively (6%).

3. (11%) Determine the value of the resistance that will absorb the maximum power (4%) when connected to terminals a and b of the circuit below (7%) and the absorbed maximum power (4%).

4. (12%) Consider the circuit shown below, where \( R_1 = 2\Omega \), \( R_2 = 1\Omega \) and \( L = 1H \), and i is the current in the inductor.

(a) Suppose \( i(0) = 0 \) and \( v_s(t) = 1(t) \) is the unit-step function, compute \( i(t) \) for \( t \geq 0 \).

(b) Suppose \( i(0) = 1A \) and \( v_s(t) = 0 \) for \( t \geq 0 \), compute \( i(t) \) for \( t \geq 0 \).

(c) Now with \( i(0) = 2A \) and \( v_s(t) = 1(t) \), compute \( i(t) \) for \( t \geq 0 \).
5. (9%) Are the following True (T) or False (F)?

(a) Time constant of a first-order $RL$ circuit increases as the resistance increases.

(b) Increase the resistance of a second-order serial $RLC$ circuit (while $C$ and $L$ remain unchanged) increases damping (ratio) of the circuit.

(c) Current in an inductor is continuous (as a function of time) if the voltage across it is bounded.

6. (12%) Consider the parallel $RLC$ circuit shown below, where $R = 5\Omega$, $C = 1F$ and $L = 1H$

(a) Write a second-order differential equation, in $i_L$, describing the circuit.

(b) Is the circuit overdamped, underdamped or critically damped?

(c) Suppose $i_s(t)$ is a unit-step function, $i_L(0) = 0$ and $v_C(0) = 0$, compute $v_C(t)$, $i_L(t)$ and the instantaneous energy stored in the capacitor and the inductor for $t \geq 0$.

7. (10%) In the circuit shown below, $R_1 = 4\Omega$, $R_2 = 2\Omega$, $L_1 = 8H$. $L_2 = 6H$, and $M = 4H$. If $E = 36V$, $i_2(0) = 0$, and $S$ is closed at $t = 0$. Find $i_1(t)$ and $i_2(t)$.

8. (12%) In the circuit shown below, let $G = \frac{1}{R}$. Find the resonant frequency $\omega_r$ and the input impedance at $\omega_r$.
9. (12%) A balanced $\Delta - \Delta$ connected three-phase system is shown below. Let $V_p = 380V$, $Z_1 = 0.1 + j0.2\Omega$, $Z_2 = 0.15 + j0.45\Omega$ and $Z = 12 + j9\Omega$. Find $I_A$, $I_B$, $I_C$, and the average power delivered to the load.