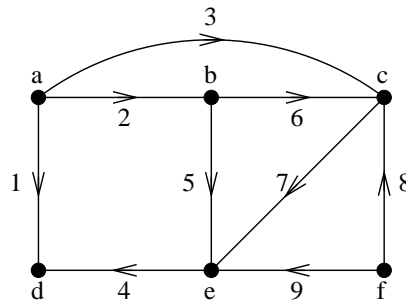**Q1.** Consider the circuit graph below.

Figure 1: The circuit graph of Q1.

1. Write the incidence and mesh matrices.

2. Pick a reference node and write the reduced incidence matrix.

3. Pick a tree and write all the associated fundamental cutsets and fundamental loops.

4. Obtain set of independent current equations using (i) the reduced incidence matrix and (ii) fundamental cutsets.

5. Obtain set of independent voltage equations using (i) the mesh matrix and (ii) fundamental loops.

6. Express the branch voltages in terms of (i) node voltages and (ii) tree branch voltages.

7. Express the branch currents in terms of (i) mesh currents and (ii) cotree branch currents.

8. Choose nonzero arbitrary branch currents and branch voltages so as to satisfy the KCL and KVL, respectively. Verify Tellegen's theorem for the choice you made.

**Q2.** Let $\hat{G}$ be the dual of the graph in Fig. 1. Repeat Q1 for $\hat{G}$.

Q3. For each of the below circuit matrices obtain the circuit graph.

$$A = \begin{bmatrix} 1 & 1 & 1 & -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & -1 & -1 & 0 \\ -1 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & -1 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \qquad M = \begin{bmatrix} -1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & -1 & 1 & 0 \\ 0 & 0 & 0 & 0 & -1 & -1 \end{bmatrix}$$

Q4. Classify the following resistors as linear/nonlinear, time-invariant/time-varying, bilateral/nonbilateral, passive/active, voltage-controlled or not, current-controlled or not.

1. $2v - 3i = 0$.

2. $2v - 3i = 4$.

3. $2v + 3i = 0$.

4. $i = [3\cos(t)]v$.

5. $v = [3 + 2\cos(4t + 30°)]i$.

6. $v = [2 + \cos(3t)]i + 4$.

7. $i = 4e^{-v/6}$.

8. $i = 4[e^{v/6} - 1]$.

9. $i = 3v^4$.

10. $v = i^5$.

11. $i = \begin{cases} v^2 & \text{for} \quad v \geq 0 \\ 0 & \text{for} \quad v < 0 \end{cases}$

12.
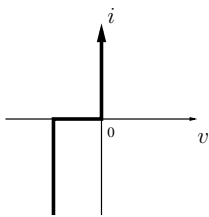
Q5. Consider the circuit in Fig. 2. Find v. Also, compute the powers delivered to (supplied by) the elements.
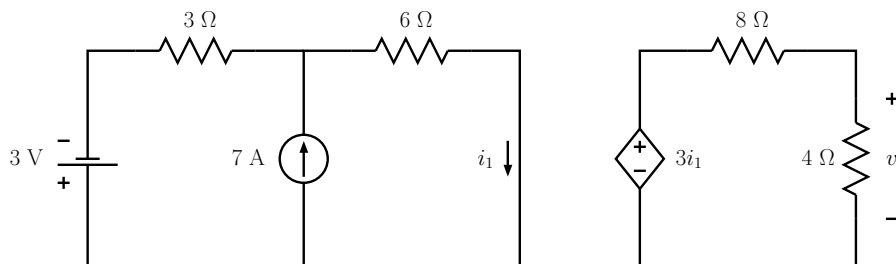

Figure 2: The circuit of Q5.

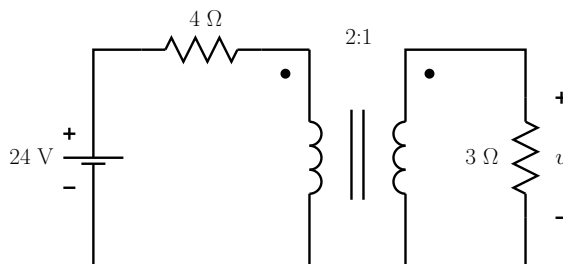**Q6.** Repeat Q5 for the circuit in Fig. 3.

Figure 3: The circuit of Q6.

Q7. Consider the circuit in Fig. 4. Compute the energy supplied by the voltage source on the interval [2sec, 3sec].
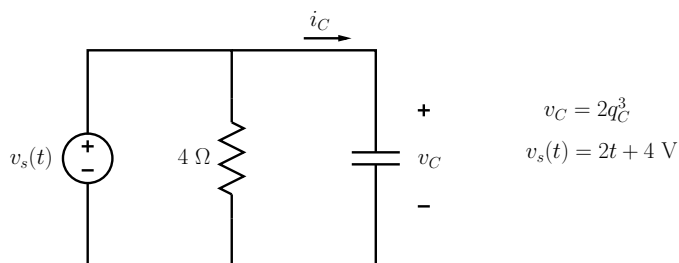

Figure 4: The circuit of Q7.

Q8. Consider the circuit in Fig. 5. Find $v(t)$. Compute the energy delivered to the inductor on the interval [2sec, 3sec].
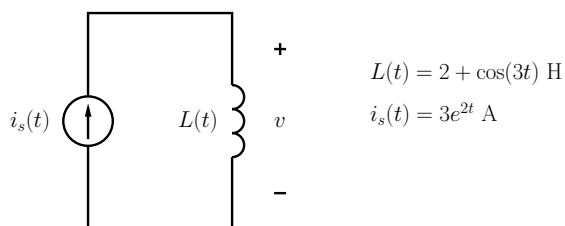

Figure 5: The circuit of Q8.

Remark. You are strongly encouraged to attempt the rest of the problems in the problem set ZPS I, which is available on the course web site.