# Control System - Assignment
# Problem 20

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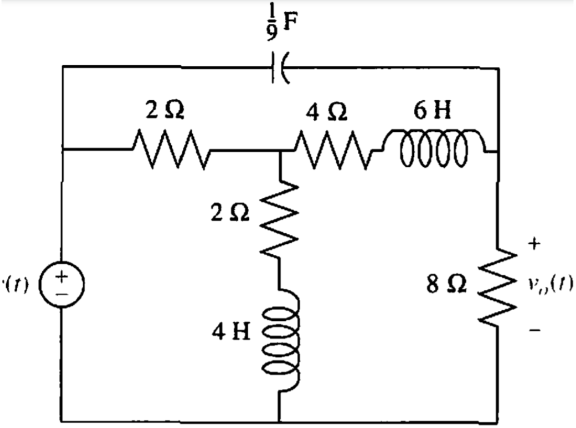
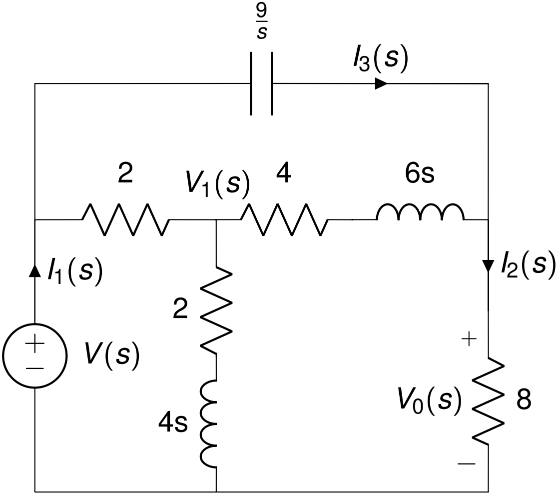
# Question-(a)

Write, but do not solve, the mesh and nodal equations for the network of Figure given below.



Assuming current $i_1(t)$ in the bottom left loop ,$i_2(t)$ in bottom right loop and $i_3(t)$ in top loop
Assuming Voltage $v_1(t)$ in the middle node.
After converting into laplace domain we get the below circuit -



# Mesh equations

Using Mesh analysis we get the below equations -

$$(4+4s)I_1(s) - (2+4s)I_2(s) - 2I_3(s) = V(s)$$

$$-(2+4s)I_1(s) + (14+10s)I_2(s) - (4+6s)I_3(s) = 0$$

$$-2I_1(s) - (4+6s)I_2(s) + (6+6s+\frac{9}{s})I_3(s) = 0$$

# Nodal equations

Using Nodal analysis we get the below equations -

$$\frac{(V_1(s) - V(s))}{2} + \frac{V_1(s)}{2 + 4s} + \frac{(V_1(s) - V_0(s))}{4 + 6s} = 0$$

$$\frac{(V_0(s) - V_1(s))}{4 + 6s} + \frac{V_0(s)}{8} + \frac{(V_0(s) - V(s))}{\frac{9}{s}} = 0$$

# Question-(b)

Use Python, and the equations found in part a to solve for the transfer function, $G(s) = V_0(s)/V(s)$. Use both the mesh and nodal equations and show that either set yields the same transfer function

# Python code

```python
import sympy as sp
I1,I2,I3,V1,V,V0,s = sp.symbols(' I1 I2 I3 V1 V V0 s');
#Mesh equations
meq1 = (4+4*s)*I1 - (2+4*s)*I2 - 2*I3 - V
meq2 = -(2+4*s)*I1 + (14+10*s)*I2 - (4+6*s)*I3
meq3 = -2*I1 - (4+6*s)*I2 + (6+6*s+9/s)*I3
sol = sp.solve((meq1,meq2,meq3),(I1,I2,I3))
G1 = 8*sol[I2]/V
print(G1)

#Nodal equations
neq1 = (V1 - V)/2 + V1/(2 + 4*s) + (V1 - V0) /(4 + 6*s)
neq2 = (V0 - V1)/(4 + 6*s) + V0/8 + (V0 - V)/9*s
sol = sp.solve((neq1,neq2),(V1,V0))
G2 = sol[V0]/V
print(G2)
```

# Output

We can see in the terminal below that the transfer functions obtained from both mesh and nodal equations are same

```
4*(12*s**3 + 24*s**2 + 28*s + 9)/(48*s**3 + 150*s**2 + 220*s + 117)
4*(12*s**3 + 24*s**2 + 28*s + 9)/(48*s**3 + 150*s**2 + 220*s + 117)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(program exited with code: 0)
Press return to continue
```