

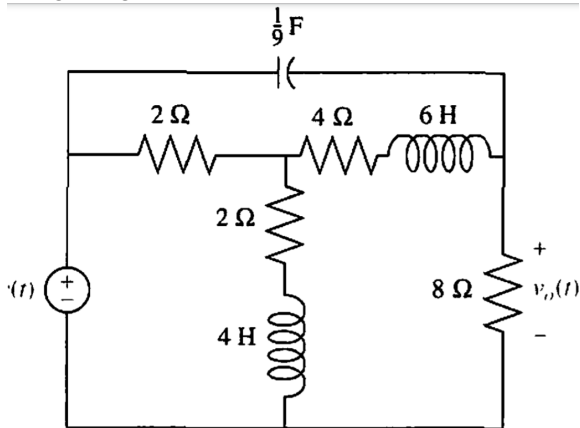
# Control System - Assignment Problem 20

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## Question-(a)

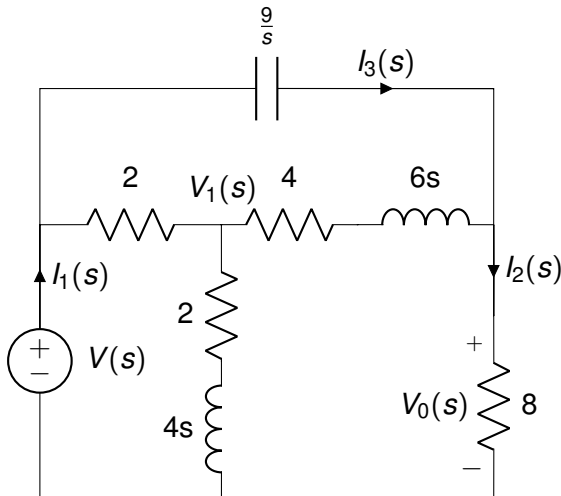
Write, but do not solve, the mesh and nodal equations for the network of Figure given below.



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)

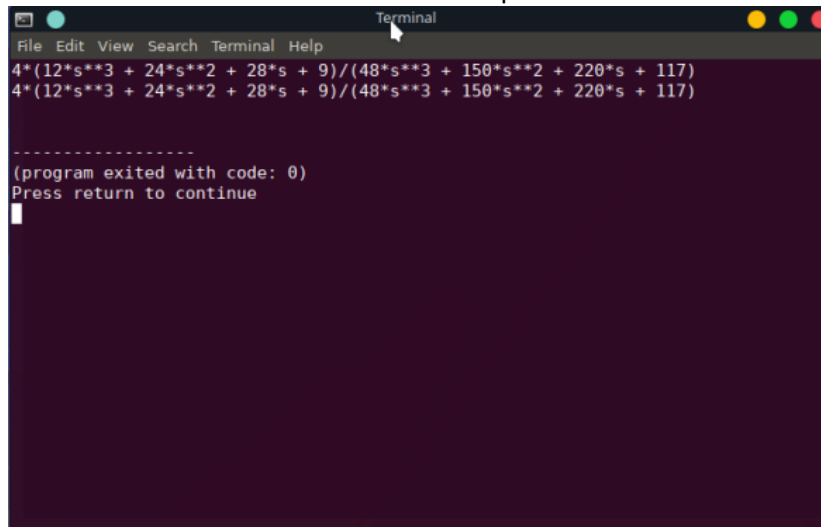
Use Python, and the equations found in part a to solve for the transfer function,  $G(s) = V_0(s)/V(s)$ . Use both the mesh and nodal equations and show that either set yields the same transfer function

# Python code

```
1 import sympy as sp
2 I1, I2, I3, V1, V, V0, s = sp.symbols(' I1 I2 I3 V1 V V0 s');
3 #Mesh equations
4 meq1 = (4+4*s)*I1 - (2+4*s)*I2 - 2*I3 - V
5 meq2 = -(2+4*s)*I1 + (14+10*s)*I2 - (4+6*s)*I3
6 meq3 = -2*I1 - (4+6*s)*I2 + (6+6*s+9/s)*I3
7 sol = sp.solve((meq1, meq2, meq3), (I1, I2, I3))
8 G1 = 8*sol[I2]/V
9 print(G1)
10
11 #Nodal equations
12 neq1 = (V1 - V)/2 + V1/(2 + 4*s) + (V1 - V0)/(4 + 6*s)
13 neq2 = (V0 - V1)/(4 + 6*s) + V0/8 + (V0 - V)/9*s
14 sol = sp.solve((neq1, neq2), (V1, V0))
15 G2 = sol[V0]/V
16 print(G2)
```

# Output

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

A screenshot of a macOS Terminal window. The title bar is dark gray with the word "Terminal" in white. Below the title bar is a menu bar with "File", "Edit", "View", "Search", "Terminal", and "Help" in white. The main area of the terminal has a dark purple background with white text. It displays two identical lines of a transfer function:  $4*(12*s^{**3} + 24*s^{**2} + 28*s + 9)/(48*s^{**3} + 150*s^{**2} + 220*s + 117)$ . After the second line, there is a dashed line separator, followed by the text "(program exited with code: 0)" and "Press return to continue". A white cursor is visible on the line "Press return to continue".

```
Terminal
File Edit View Search Terminal Help
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
```