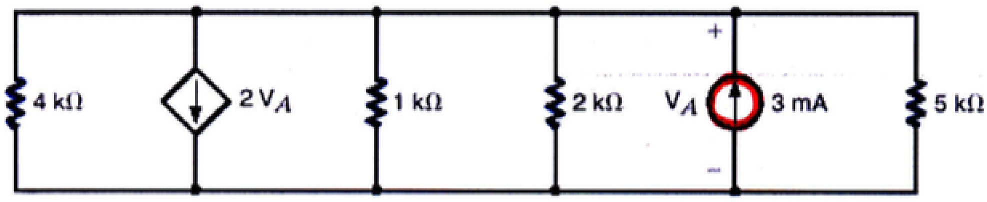
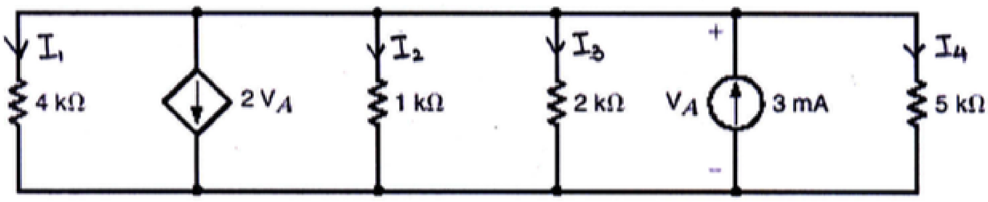
Question 1

Find the power absorbed by the dependent source in the network below.



Solution:



KCL: $3m = I_1 + 2V_A + I_2 + I_3 + I_4$

$I_1 = \frac{V_A}{4K}$,$I_2 = \frac{V_A}{1K}$,$I_3 = \frac{V_A}{2K}$ and $I_4 = \frac{V_A}{5K}$

$3m = \frac{V_A}{4K} + 2V_A + \frac{V_A}{1K} + \frac{V_A}{2K} + \frac{V_A}{5K}$

$60 = 5V_A + 40KV_A + 20V_A + 10V_A + 4V_A$

$V_A = 1.5mV$

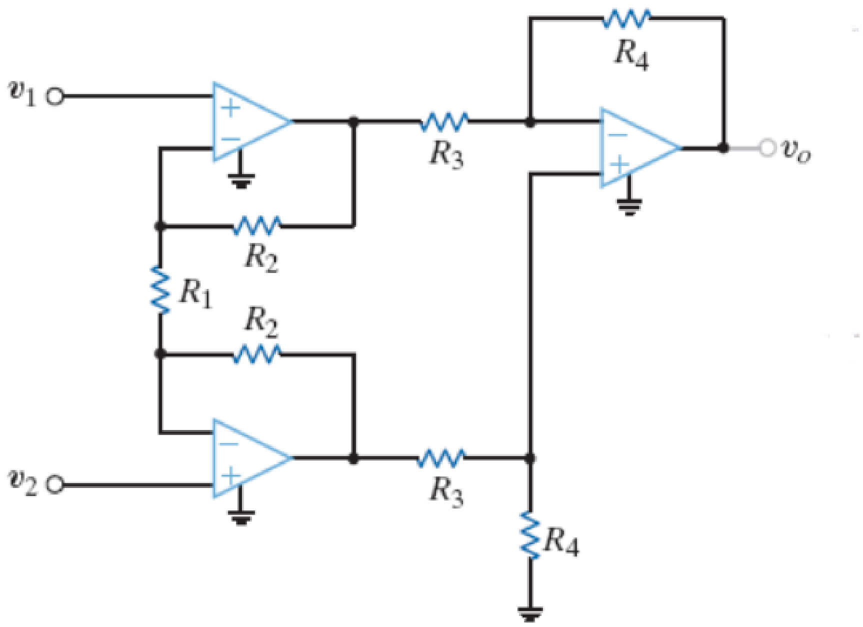
$P_{2V_A} = V_A I = V_A(2V_A)$

$P_{2V_A} = (1.5m)(2)(1.5m)$

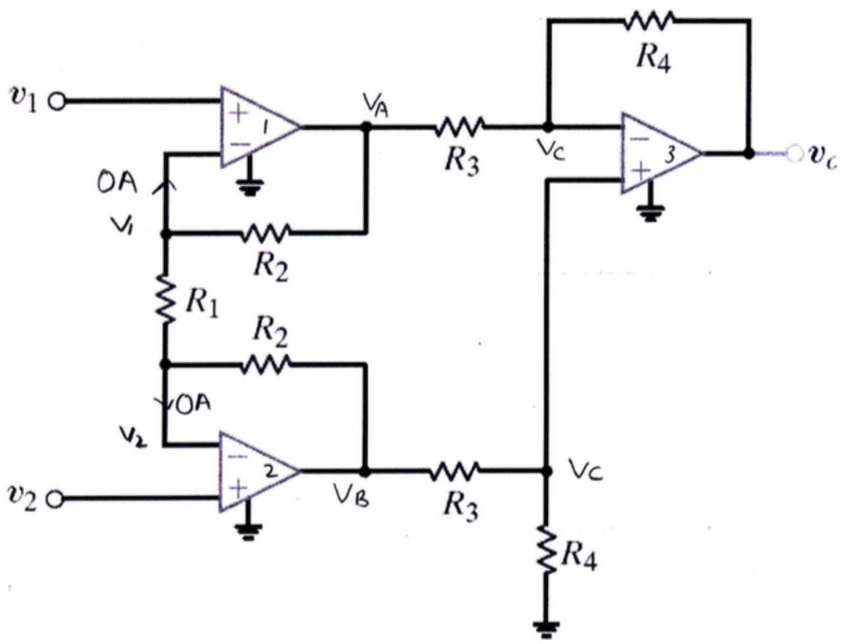
$P_{2V_A} = 4.5\mu W$

Question 2

Find the output voltage, V_O, in the circuit below.



Solution:



KCL at V_- of op-amp 1:

$\frac{V_A - V_1}{R_2} = \frac{V_1 - V_2}{R_1}$

$V_A = \frac{V_1 - V_2}{R_1} R_2 + V_1$
$V_A = (1 + \frac{R_2}{R_1}) V_1 - \frac{R_2}{R_1} V_2$

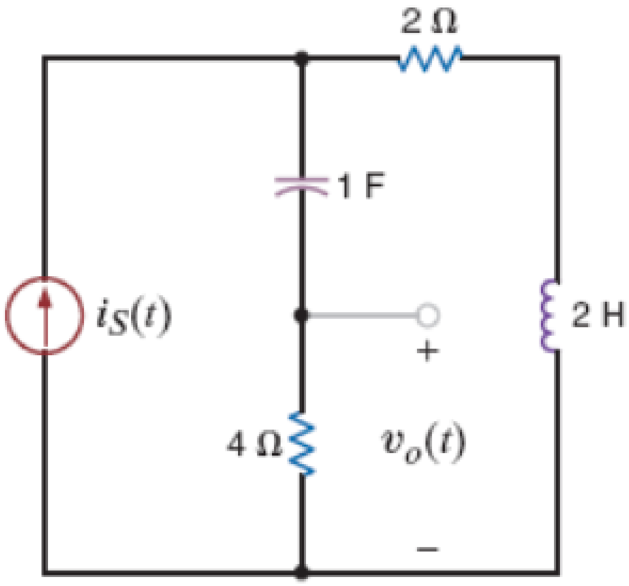
KCL at V_- of op-amp 2:
$\frac{V_B - V_2}{R_2} = \frac{V_2 - V_1}{R_1}$
$V_B = -\frac{V_1}{R_1} R_2 + \frac{V_2}{R_1} R_2 + V_2$
$V_B = (1 + \frac{R_2}{R_1}) V_2 - \frac{R_2}{R_1} V_1$

KCL at V_+ of op-amp 3:
$\frac{V_B - V_C}{R_3} = \frac{V_C}{R_4}$
$V_C (\frac{1}{R_4} + \frac{1}{R_3}) = \frac{V_B}{R_3}$
$V_C = (\frac{R_4}{R_3 + R_4}) V_B$

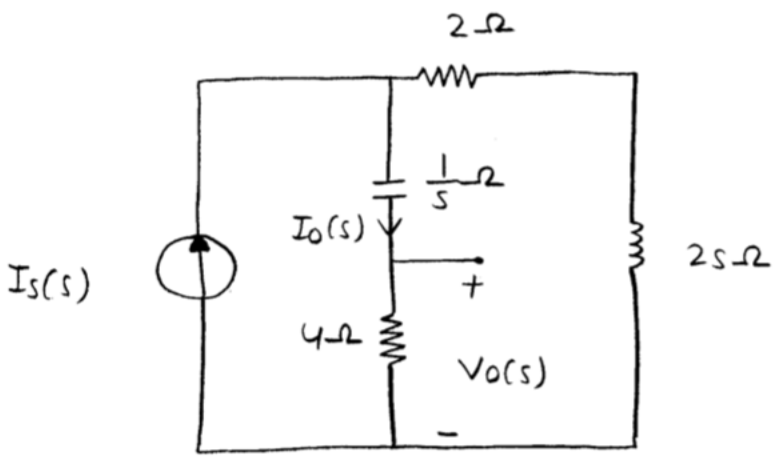
KCL at V_- of op-amp 3:
$\frac{V_A - V_C}{R_3} + \frac{V_O - V_C}{R_4} = 0$
$V_O = -\frac{V_A}{R_3} R_4 + \frac{V_C}{R_3} R_4 + V_C$
$V_O = -\frac{V_A}{R_3} R_4 + (1 + \frac{R_4}{R_3}) V_C$
$V_O = -\frac{R_4}{R_3} \left[(1 + \frac{R_2}{R_1}) V_1 - \frac{R_2}{R_1} V_2 \right] + (1 + \frac{R_4}{R_3})(\frac{R_4}{R_3 + R_4}) \left[(1 + \frac{R_2}{R_1}) V_2 - \frac{R_2}{R_1} V_1 \right]$
$V_O = \frac{R_4}{R_3} (1 + 2\frac{R_2}{R_1})(V_2 - V_1)$

Question 3

Find the transfer impedance $V_o(s)/I_s(s)$ for the network.



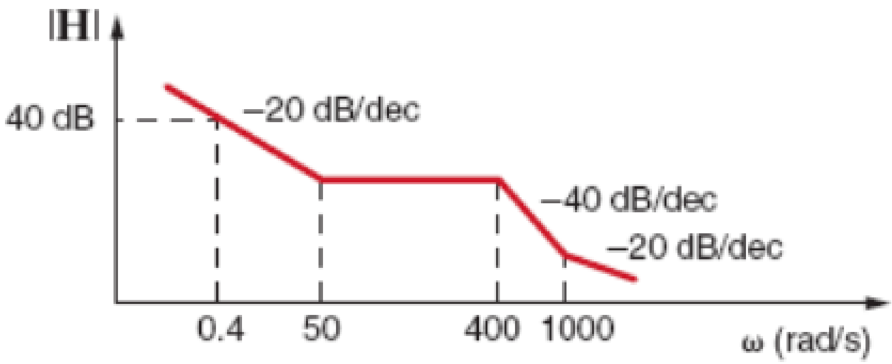
Solution:



$$I_o = I_s\left(\frac{2+2s}{2+2s+\frac{1}{s}+4}\right)$$
$$I_o = I_s\left[\frac{s(2+2s)}{2s+2s^2+1+4s}\right]$$
$$I_o = I_s\left(\frac{2+2s}{2s^2+6s+1}\right)$$
$$\frac{I_o}{I_s} = \frac{2+2s}{2s^2+6s+1}$$
$$\frac{V_o}{I_s} = \frac{4I_o}{I_s} = 4\left[\frac{2s(s+1)}{2s^2+6s+1}\right]$$
$$\frac{V_o}{I_s} = \frac{8s(s+1)}{2s^2+6s+1}$$

Question 4

Find $\boldsymbol{H}(j\omega)$ if its magnitude characteristic is shown below.



Solution:

Poles exist at:

double pole at 400 rad/s

zeroes exist at: 50 rad/s and 1000 rad/s.

$H(j\omega) = \frac{K(j\omega+50)(j\omega+1000)}{j\omega(j\omega+400)^2}$

at $\omega = 0.4rad/s$

$|H(j\omega)| = 40dB = 100$

$100 = \frac{K(50)(1000)}{0.4(400)^2}$

$K = 128$

$H(j\omega) = \frac{128(j\omega+50)(j\omega+1000)}{j\omega(j\omega+400)^2}$