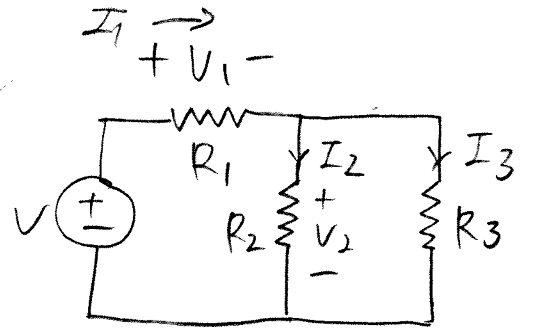
EECS 311 PS1 Solution

P1.1

1.20



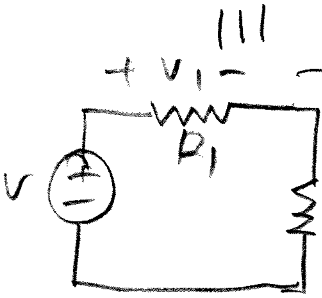
$V = 10V$

$R_1 = 22k\Omega$

$R_2 = 47k\Omega$

$R_3 = 180k\Omega$

V_1, V_2, I_2, I_3



$R_2 // R_3 = 47k\Omega // 180k\Omega = 37.26k\Omega$

$$I_1 = \frac{V}{R_1 + (R_2 // R_3)} = \frac{10}{22k + 37.26k} = 0.168mA$$

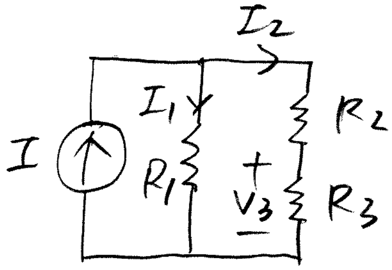
$$\therefore V_1 = I_1 R_1 = 0.168m \times 22k = \boxed{3.69\ V} \ \#$$

$$V_2 = V - V_1 = 10 - 3.69 = \boxed{6.31\ V} \ \#$$

$$I_2 = \frac{V_2}{R_2} = \frac{6.31}{47k} = \boxed{0.134\ mA} \ \#$$

$$I_3 = \frac{V_2}{R_3} = \frac{6.31}{180k} = \boxed{0.035\ mA} \ \#$$

1.22



$I = 5mA$

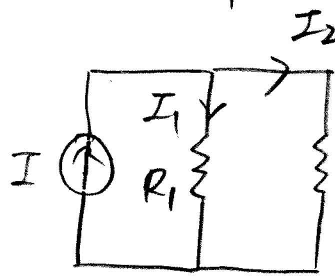
$R_1 = 2.4\,k\Omega$

$R_2 = 5.6\,k\Omega$

$R_3 = 3.6\,k\Omega$

I_1, I_2, V_3 ? p.

$\equiv$



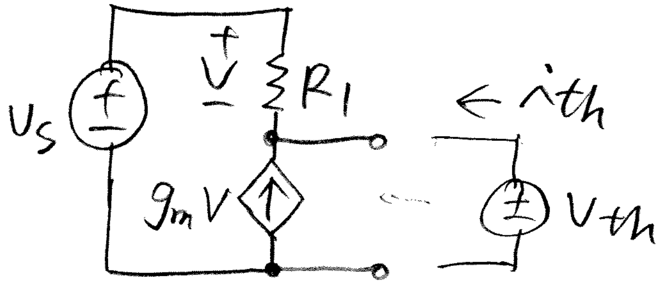
$R_{eq} = R_2 + R_3 = 9.2\,k\Omega$

$$I_1 = I \times \frac{R_{eq}}{R_1 + R_{eq}} = 5m \times \frac{9.2k}{2.4k + 9.2k} = \boxed{3.97m}$$

$$I_2 = I \times \frac{R_1}{R_1 + R_{eq}} = 5m \times \frac{2.4k}{2.4k + 9.2k} = \boxed{1.03mA}$$

$$V_3 = I_2 R_3 = 1.03m \times 3.6k = \boxed{3.71V}$$ #

1.24 ✓



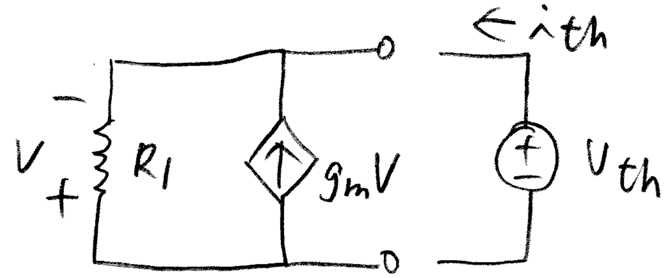
① find open circuit voltage

$g_m V + \frac{V}{R} = 0 \Rightarrow$ only $V = 0$ will satisfy

$\therefore \boxed{V_{th} = V_s}$

② find short circuit current

$i_{th} = -g_m V - \frac{V}{R_1}$



$\because V = -V_{th} \Rightarrow \boxed{i_{th} = g_m V_{th} + \frac{V_{th}}{R_1}}$

$R_{th} = \frac{V_{th}}{i_{th}} = \frac{1}{g_m + \frac{1}{R_1}} = \boxed{R_1 \parallel \frac{1}{g_m}}$

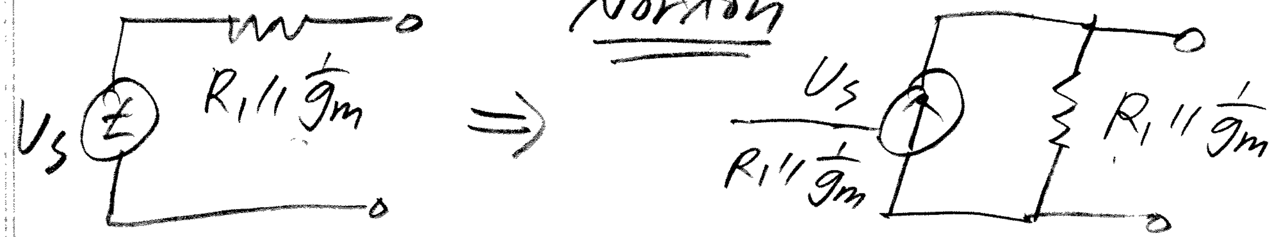
$= 50K \parallel \frac{1}{0.002} = \boxed{495\,\Omega}$

#

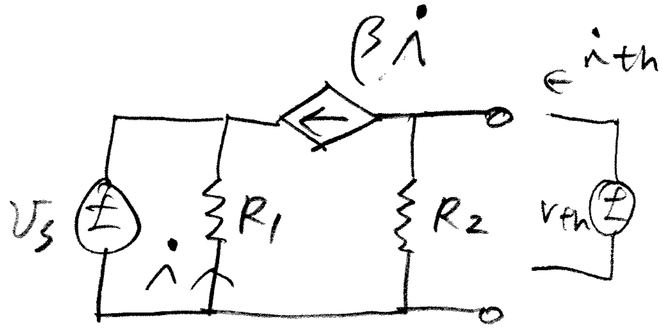
$= 40$
$= 4K \parallel \frac{1}{0.025}$

1.25 From 1.24,
We know that $V_{th} = V_s$, $R_{th} = R_1 \parallel \frac{1}{g_m}$

Norton



1.26(a)

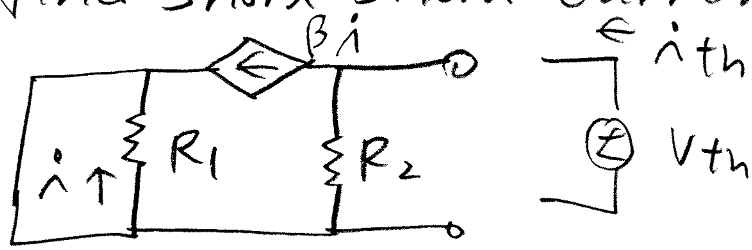


$\beta = 120$, $R_1 = 100k\Omega$
$R_2 = 39k\Omega$

① find open circuit voltage:

$i = \frac{-V_s}{R_1}$, $V_{th} = -\beta i \cdot R_2 = V_s \beta \frac{R_2}{R_1}$

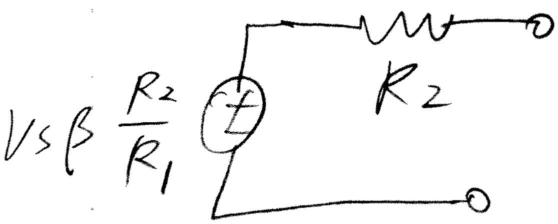
② find short short current:



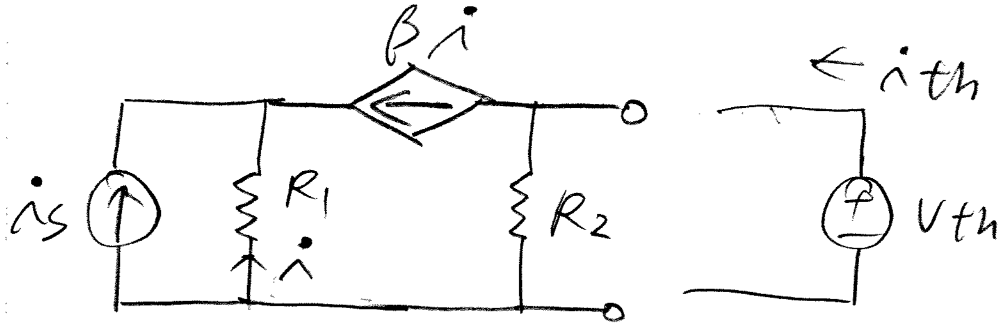
current won't flow into R_1 ⇒ $i = 0$

$\therefore R_{th} = R_2 = 39K\Omega$

Thevenin equivalent



1.26(b) ✓



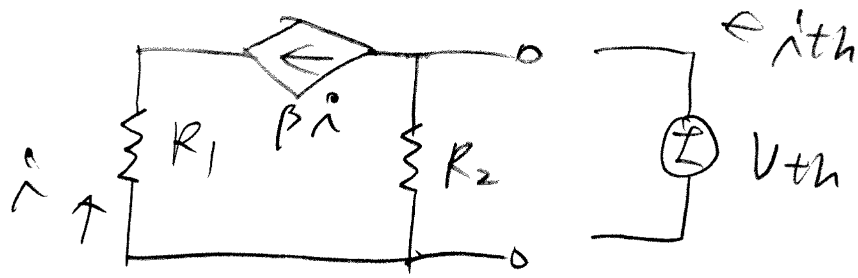
① open circuit voltage :

$V_{th} = -\beta i R_2$

$i = -i_s - \beta i \Rightarrow i = \frac{-i_s}{1+\beta}$

$V_{th} = i_s \frac{\beta}{1+\beta} R_2$

② short circuit current :

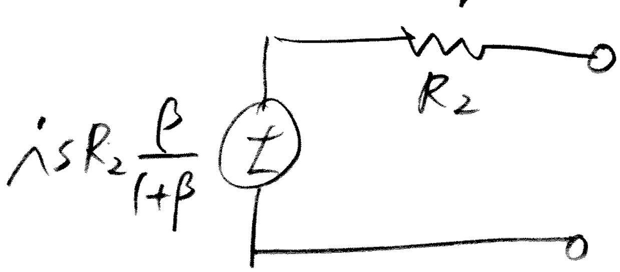


KCL : $i + \beta i = 0 \Rightarrow i = 0$

$i_{th} = \frac{V_{th}}{R_2} + \cancel{\beta i} = \frac{V_{th}}{R_2}$

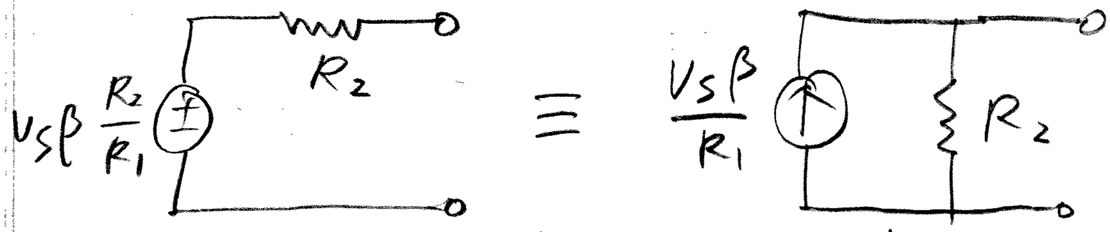
$R_{th} = \frac{V_{th}}{i_{th}} = R_2 = 39k\Omega$

Thevenin equivalent circuit

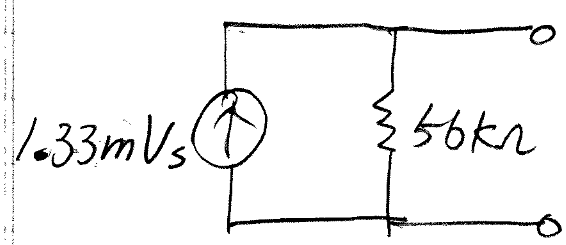


1.27

from 1.26 (a)



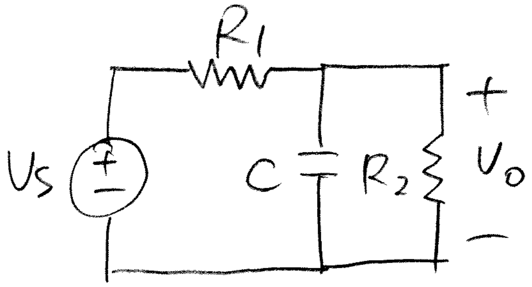
$\beta = 100$, $R_1 = 75\,k\Omega$, $R_2 = 56\,k\Omega$



Norton equivalent

P1.2

10.37 ✓



$$\frac{V_o}{V_S} = \frac{R_2}{R_1+R_2}\left(\frac{1}{1+\frac{s}{\omega_H}}\right)$$

$R_1 = 1k\Omega$, $R_2 = 1.5k\Omega$, $C = 0.01\mu F$

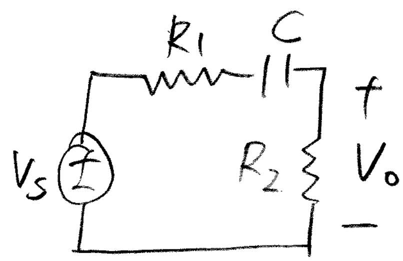
$$A_V(s) = \frac{\frac{\cancel{R_2}}{R_1+R_2}}{1+\frac{s}{\omega_H}}$$

$$A_0 = \frac{R_2}{R_1+R_2} = \frac{1.5}{1+1.5} = \boxed{0.6} = -4.4\,dB$$

$$f_H = \frac{1}{2\pi}\frac{1}{(R_1 \| R_2)C} = \frac{1}{2\pi} \times \frac{1}{(1k \| 1.5k) \times 0.01\mu}$$

$$= \boxed{26.52\,kHz}$$

10.40 ✓



$$\frac{V_o}{V_S} = \left(\frac{R_2}{R_1+R_2}\right)\left(\frac{S}{S+\omega_L}\right)$$

$R_1 = 8.2k\Omega$, $R_2 = 20k\Omega$, $C = 0.01\mu F$

$$A_V(s) = \frac{\frac{R_2}{R_1+R_2}}{1+\frac{\omega_L}{S}}$$

$$A_0 = \frac{R_2}{R_1+R_2} = \frac{20}{8.2+20} = \boxed{0.71} \approx -3\,dB$$

$$f_H = \frac{1}{2\pi} \times \frac{1}{(R_1+R_2)C} = \frac{1}{2\pi} \times \frac{1}{28.2K \times 0.01\mu}$$

$$= \boxed{564\,Hz}$$

#

10.43 $A_v(s) = \dfrac{2\pi \times 10^7 s}{(s+20\pi)(s+2\pi\times 10^4)}$

$= \dfrac{1000}{(1+\frac{20\pi}{s})(1+\frac{s}{2\pi\times 10^4})}$

$A_0 = 1000 = \boxed{60 dB}$ #

$f_H = \dfrac{\cancel{2\pi}\times 10^4}{\cancel{2\pi}} = \boxed{10 kHz}$ #

$f_L = \dfrac{20\pi}{2\pi} = \boxed{10 Hz}$ #

$BW = f_H - f_L = 10k - 10 = \boxed{9.99 kHz}$ #

$\boxed{\text{Band-pass amplifier}}$ #

10.44 $A_v(s) = \dfrac{10^4 s}{s+200\pi} = \dfrac{10^4}{1+\frac{200\pi}{s}}$

$A_0 = 10^4 = \boxed{80 dB}$ #

$f_H = \boxed{\infty}$ #

$f_L = \dfrac{200\cancel{\pi}}{2\cancel{\pi}} = \boxed{100 Hz}$ #

$BW = f_H - f_L = \boxed{\infty}$ #

$\boxed{\text{high-pass amplifier}}$ #

10.45 ✓

$$A_v(s) = \frac{2\pi \times 10^6}{s + 200\pi} = \frac{10^4}{1 + \frac{s}{200\pi}}$$

$A_0 = 10^4 = \boxed{80\,dB}$ #

$f_H = \frac{200\pi}{2\pi} = \boxed{100\,Hz}$ #

$f_L = \boxed{0\,Hz}$ #

$BW = f_H - f_L = \boxed{100\,Hz}$ #

$\boxed{\text{Low-pass amplifier}}$ #

10.46 ✓

$$A_v(s) = \frac{-10^7 s}{s^2 + 10^5 s + 10^{14}}$$

It's in the form of $\boxed{\text{narrow band pass amplifier}}$ #

$$A_v(s) = A_0 \frac{s\frac{\omega_0}{Q}}{s^2 + s\frac{\omega_0}{Q} + \omega_0^2}, \quad \boxed{A_0 = -100}$$ #

$\omega_0^2 = 10^{14} \Rightarrow f_0 = \frac{1}{2\pi}\sqrt{10^{14}} = 1.59 \times 10^6\,Hz$

$\frac{\omega_0}{Q} = 10^5 \Rightarrow Q = 10^2 = \boxed{100}$ #

$BW = \frac{f_0}{Q} = \frac{1.59 \times 10^6}{100} = \boxed{1.59 \times 10^4\,Hz}$ #

$f_H = f_0 + \frac{BW}{2} = 1.59 \times 10^6 + 0.795 \times 10^4 = \boxed{1597950\,Hz}$ #

$f_L = f_0 - \frac{BW}{2} = 1.59 \times 10^6 - 0.795 \times 10^4 = \boxed{1582050\,Hz}$ #

10.47 $A_v(s) = -20 \dfrac{s^2+10^{12}}{s^2+10^4 s+10^{12}}$

✓ It's in the form of $\boxed{\text{band-rejection amplifiers}}$ #

$A_v(s) = A_0 \dfrac{s^2+\omega_0^2}{s^2+s\frac{\omega_0}{Q}+\omega_0^2}$

$\omega_0^2 = 10^{12} \Rightarrow f_0 = \frac{1}{2\pi}\sqrt{10^{12}} = 159155\ Hz$

$\frac{\omega_0}{Q} = 10^4 \Rightarrow Q = 10^2 = 100$

$BW = \dfrac{f_0}{Q} = \dfrac{159155}{100} = \boxed{1591.55\ Hz}$ #

$f_H = f_0 + \frac{BW}{2} = 159155 + \frac{1591.55}{2} = \boxed{159951\ Hz}$ #

$f_L = f_0 - \frac{BW}{2} = 159155 - \frac{1591.55}{2} = \boxed{158359\ Hz}$ #

10.48

✓ $A_v(s) = \dfrac{4\pi^2 \times 10^{14} s^2}{(s+20\pi)(s+50\pi)(s+2\pi\times10^5)(s+2\pi\times10^6)}$

$= \dfrac{1000}{(1+\frac{20\pi}{s})(1+\frac{50\pi}{s})(1+\frac{s}{2\pi\times10^5})(1+\frac{s}{2\pi\times10^6})}$

$A_0 = 1000 = \boxed{60\ dB}$ #

The midband gain is always defined as the region of highest gain, and the cutoff frequencies are defined in terms of the midband gain.

$|A_v(j\omega_L)| = \dfrac{A_0}{\sqrt{2}} = |A_v(j\omega_H)|$

$f_{L1} = \frac{20\pi}{2\pi} = 10\ Hz$ $\qquad f_{H1} = 10^5\ Hz$ #

$f_{L2} = \frac{50\pi}{2\pi} = 25\ Hz$ $\qquad f_{H2} = 10^6\ Hz$ $\qquad f_H = 10^5$

check the freq in the above equation $\Rightarrow \boxed{f_L = 25\ Hz},$

P1.3 10.43 ✓

$V_{in}(s) = 1\angle 0°,\ \omega = 2000\pi$

$$A_v(s) = \frac{1000}{\left(1+\frac{20\pi}{s}\right)\left(1+\frac{s}{2\pi\times 10^4}\right)}$$

$$|A_v(j2000\pi)| = \frac{1000}{\sqrt{\left(\frac{1001}{1000}\right)^2 + \left(\frac{9}{100}\right)^2}} = 707.107$$

$$\angle A_v(j2000\pi) = \angle 1000° - \tan^{-1}\frac{\frac{9}{100}}{\frac{1001}{1000}} = -5.137°$$

Phasor form

$$A_v(s) = \frac{1000}{\sqrt{2}}\angle -5.137°$$

$$V_{out}(t) = A_v(s) \times V_{in}(t)$$

$$= \left(\frac{1000}{\sqrt{2}}\angle -5.137°\right) \times (1\angle 0°)$$

$$= \frac{1000}{\sqrt{2}}\angle -5.137°$$

$$\Rightarrow \boxed{V_{out}(t) = 707.107\cos(2\pi \times 1000t - 5.137°)}$$

$|V_{out}| = 20\log(707.107) = 57\,dB$ #

10.44

$V_{in}(t) = 1\angle 0°$, $\omega = 2000\pi$

$$A_v(s) = \frac{10^4}{1 + \frac{200\pi}{s}}$$

$$A_v(j2000\pi) = \frac{10^4}{1 + \frac{1}{j10}}$$

$$|A_v(j2000\pi)| = \frac{10^4}{\sqrt{1 + \frac{1}{100}}} = 9950.37$$

$$\angle A_v(j2000\pi) = \angle 10^4 - \tan^{-1}\frac{\frac{1}{10}}{1} = +5.71$$

phasor form: $A_v(s) = 9950.37\angle 5.71$

$V_{out}(t) = A_v(s) \times V_{in}(t)$

$= (9950.37\angle 5.71°) \times (1\angle 0°)$

$= 9950.37\angle 5.71$

$$\Rightarrow \boxed{V_{out}(t) = 9950.37\cos(2\pi \times 1000t + 5.71°)}$$

#

$|V_{out}| = 20\log 9950.37 = 80\,dB$

10.45 ✓

$V_{in}(t) = 1\angle 0°, \quad W = 2000\pi$

$$A_v(s) = \frac{10^4}{1 + \frac{s}{200\pi}}$$

$$A_v(j2000\pi) = \frac{10^4}{1 + j10}$$

$$|A_v(j2000\pi)| = \frac{10^4}{\sqrt{1+10^2}} = 995.04$$

$$\angle A_v(j2000\pi) = \angle 10^4 - \tan^{-1}\frac{100}{1} = -89.43°$$

phasor form: $A_v(s) = 995.04\angle -89.43°$

$$V_{out}(t) = A_v(s) \times V_{in}(t)$$

$$= (995.04\angle -89.43°) \times 1\angle 0°$$

$$= 995.04\angle -89.43°$$

$$\Rightarrow \boxed{V_{out}(t) = 995.04\cos(2\pi \times 1000t - 89.43°)}$$

#

$|V_{out}| = 20\log(995.04) = 60\,dB$

10.46 ✓

$V_{in}(t) = 1\angle 0^\circ, \quad \omega = 2000\pi$

$$A_v(s) = -\frac{10^7 s}{s^2 + 10^5 s + 10^{14}} = -\frac{10^7}{s + 10^5 + \frac{10^{14}}{s}}$$

$$A_v(j2000\pi) = \frac{-10^7}{j2000\pi + 10^5 + \frac{10^{14}}{j2000\pi}} = \frac{-10^7}{10^5 - j1.59\times10^{10}}$$

$$|A_v(j2000\pi)| = \frac{10^7}{\sqrt{(10^5)^2 + (1.59\times10^{10})^2}} = 0.00063$$

$$\angle A_v(j2000\pi) = \angle -10^7 - \tan^{-1}\frac{-1.59\times10^{10}}{10^5}$$

$$= -90^\circ$$

phasor form $A_v(s) = 0.00063 \angle -90^\circ$

$V_{out}(t) = A_v(s) \times V_{in}(t)$

$$= (0.00063\angle -90^\circ) \times (1\angle 0^\circ)$$

$$= 0.00063\angle -90^\circ$$

$$\Rightarrow \boxed{V_{out}(t) = 0.00063\cos(2\pi\times1000t - 90^\circ)} \quad \#$$

$|V_{out}| = 20\log 0.00063 = -64\,dB$

P1.4
10.43

$$A_v(s) = \frac{2\pi \times 10^7 s}{(s+20\pi)(s+2\pi\times 10^4)}$$

✓

Initial Value Theorem:

$$\lim_{t\to 0^+} A_v(t) = \lim_{s\to\infty} \cancel{s} \times \frac{1}{\cancel{s}} A_v(s)$$

$$= \lim_{s\to\infty} \frac{2\pi\times 10^7 s}{(s+20\pi)(s+2\pi\times 10^4)}$$

$$= \lim_{s\to\infty} \frac{10^3}{(s+20\pi)\left(\frac{1}{2\pi\times 10^7} + \frac{1}{s\times 10^3}\right)}$$

$$(\infty \times \frac{1}{\infty}) = 1$$

$$= \boxed{\cancel{1000}} \quad \#$$

$$\boxed{\lim_{s\to\infty} = 0}$$

Final Value Theorem:

$$\lim_{t\to\infty} A_v(t) = \lim_{s\to 0} \cancel{s} \times \frac{1}{\cancel{s}} A_v(s)$$

$$= \lim_{s\to 0} \frac{2\pi\times 10^7 s}{(s+20\pi)(s+2\pi\times 10^4)}$$

$$= \lim_{s\to 0} \frac{10^3}{(s+20\pi)\left(\frac{1}{2\pi\times 10^4} + \frac{1}{s}\right)}$$

$$= \frac{10^3}{20\pi\times\infty}$$

$$= \boxed{0} \quad \#$$

10.44 $Av(s) = \frac{10^4 s}{s+200\pi}$

✓ Initial value Theorem:

$$\lim_{t\to 0^+} Av(t) = \lim_{s\to\infty} \cancel{s} \times \frac{1}{\cancel{s}} Av(s)$$

$$= \lim_{s\to\infty} \frac{10^4 s}{s+200\pi} = \lim_{s\to\infty} \frac{10^4}{1+\cancel{\frac{200\pi}{s}}_{0}}$$

$$= \boxed{10^4} \#$$

Final value Theorem:

$$\lim_{t\to\infty} Av(t) = \lim_{s\to 0} \cancel{s} \times \frac{1}{\cancel{s}} Av(s)$$

$$= \lim_{s\to 0} \frac{10^4 s}{s+200\pi} = \lim_{s\to 0} \frac{10^4}{1+\cancel{\frac{200\pi}{s}}_{\infty}}$$

$$= \boxed{0} \#$$

10.45 $Av(s) = \frac{2\pi\times 10^6}{s+200\pi}$

✓ Initial value Theorem:

$$\lim_{t\to 0^+} Av(t) = \lim_{s\to\infty} \cancel{s} \times \frac{1}{\cancel{s}} Av(s) = \lim_{s\to\infty} \frac{2\pi\times 10^6}{\cancel{s+200\pi}_{\infty}}$$

$$= \boxed{0} \#$$

Final value Theorem:

$$\lim_{t\to\infty} Av(t) = \lim_{s\to 0} \frac{2\pi\times 10^6}{s+200\pi} = \frac{10^4}{\frac{s}{200\pi}+1} = \boxed{10^4} \#$$

10.46

$$A_v(s) = -\frac{10^7 s}{s^2+10^5 s+10^{14}}$$

Initial value Theorem:

$$\lim_{t\to 0^+} A_v(t) = \lim_{s\to\infty} \cancel{s}\times\frac{1}{\cancel{s}} A_v(s)$$

$$= \lim_{s\to\infty} \frac{-10^7 s}{s^2+10^5 s+10^{14}}$$

$$= \lim_{s\to\infty} \frac{-1}{\frac{s}{10^7}+\frac{1}{10^2}+\frac{10^7}{s}} \quad = \frac{\infty}{\infty} = 1$$

$$= \boxed{-1}$$ #

Final value Theorem:

$$\lim_{t\to\infty} A_v(t) = \lim_{s\to 0} \cancel{s}\times\frac{1}{\cancel{s}} A_v(s)$$

$$= \lim_{s\to 0} \frac{-10^7 s}{s^2+10^5 s+10^{14}}$$

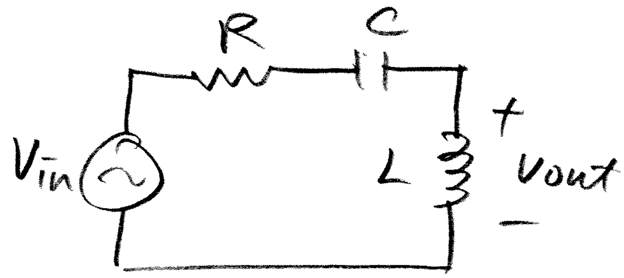
$$= \lim_{s\to 0} \frac{-1}{\frac{s}{10^7}+\frac{1}{10^2}+\frac{10^7}{s}} \to \infty$$

$$= \boxed{0}$$ #

P1.5

P.118

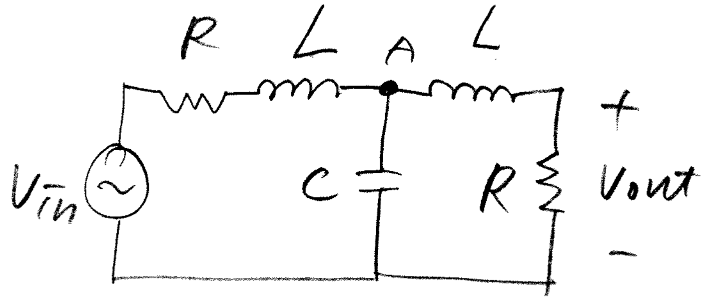
a)



Using voltage divider

$$\frac{V_{out}}{V_{in}} = \frac{sL}{R+\frac{1}{sC}+sL} = \boxed{\frac{s^2LC}{1+sRC+s^2LC}}$$ #

b)



① Find V_A

$$V_A = V_{in} \times \frac{(R+sL) \parallel \frac{1}{sC}}{R+sL+\underbrace{\left[(R+sL) \parallel \frac{1}{sC}\right]}_{\frac{R+sL}{1+sC(R+sL)}}}$$

$$V_A = V_{in} \frac{(\cancel{R+sL})}{(\cancel{R+sL})(1+sC(R+sL)) + (\cancel{R+sL})_{1}}$$

$$= V_{in} \frac{1}{2+sC(R+sL)}$$

② Find $V_{out} = f(V_A)$

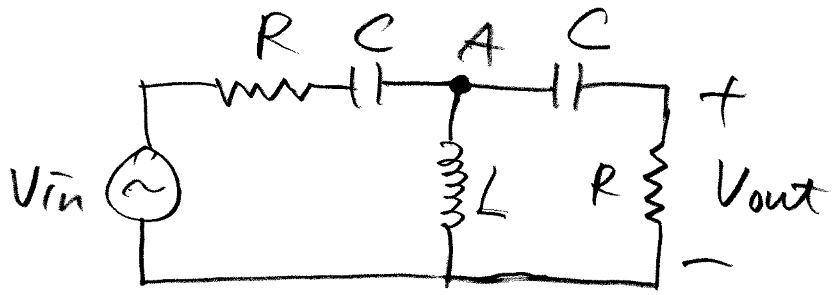
$$V_{out} = V_A \times \frac{R}{R+sL}$$

③ Substitute VA

$$V_{out} = V_{in} \times \frac{1}{2+SC(R+SL)} \times \frac{R}{R+SL}$$

$$\boxed{\frac{V_{out}}{V_{in}} = \frac{R}{(2+SC(R+SL))(R+SL)}} \#$$

c) ✓



① Find VA

$$V_A = V_{in} \times \frac{SL \,//\, (R+\frac{1}{SC})}{(R+\frac{1}{SC}) + \underbrace{(SL \,//\, (R+\frac{1}{SC}))}_{\frac{SL(R+\frac{1}{SC})}{SL+R+\frac{1}{SC}}}}$$

$$V_A = V_{in} \times \frac{SL\cancel{(R+\frac{1}{SC})}}{\cancel{(R+\frac{1}{SC})}(SL+R+\frac{1}{SC}) + SL\cancel{(R+\frac{1}{SC})}}$$

$$= V_{in} \times \frac{SL}{(SL+R+\frac{1}{SC})+SL} = V_{in}\frac{S^2LC}{1+SRC+2S^2LC}$$

② Find Vout

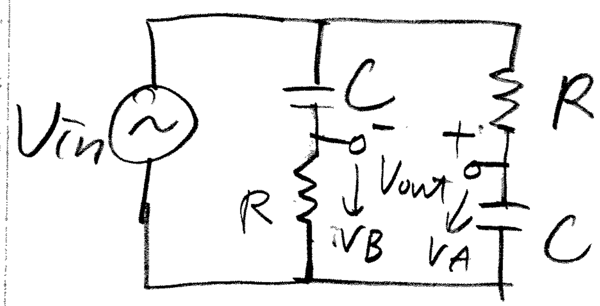
$$V_{out} = V_A \times \frac{R}{R+\frac{1}{SC}} = \frac{SRC}{1+SRC} V_A$$

③ Substitute VA

$$\frac{V_{out}}{V_{in}} = \frac{SRC}{1+SRC} \times \frac{S^2LC}{1+SRC+2S^2LC} = \frac{S^3RLC^2}{(1+SRC+2S^2LC)(1+SR}$$

P. 20

d)



$$V_{out} = V_A - V_B$$

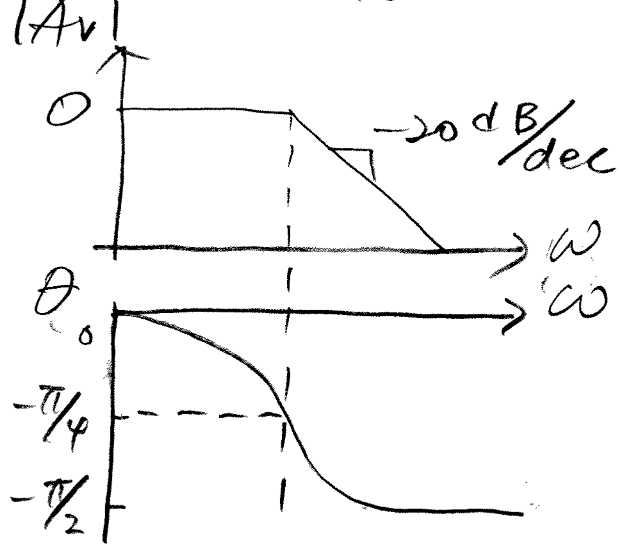
$$= V_{in} \times \frac{\frac{1}{sC}}{\frac{1}{sC} + R} - V_{in} \times \frac{R}{R + \frac{1}{sC}}$$

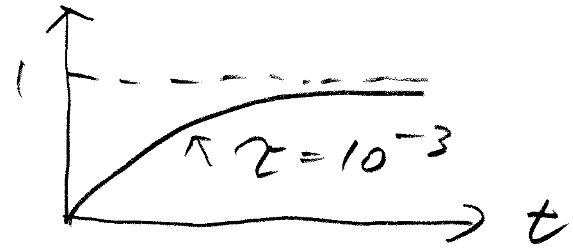
$$= V_{in} \times \left(\frac{1}{1+RsC} - \frac{RsC}{RsC+1} \right)$$

$$\boxed{\frac{V_{out}}{V_{in}} = \frac{1-RsC}{1+RsC}}$$ #

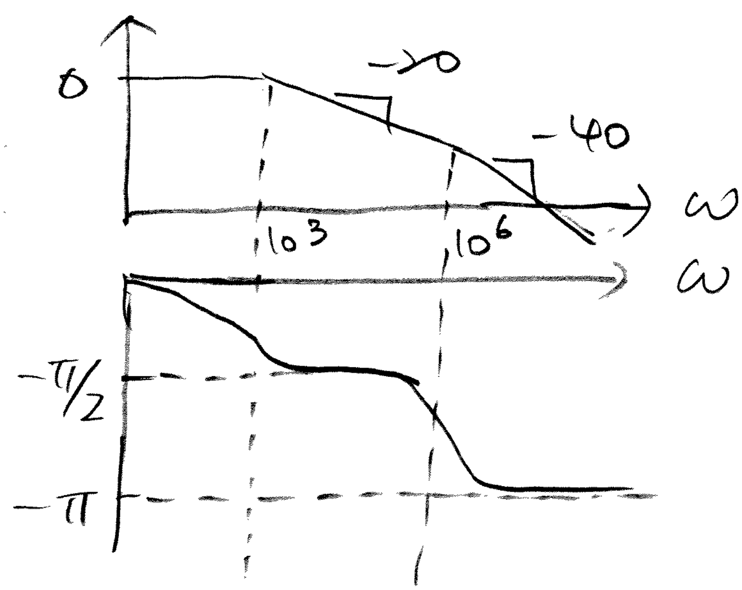
P1.6 p. 21

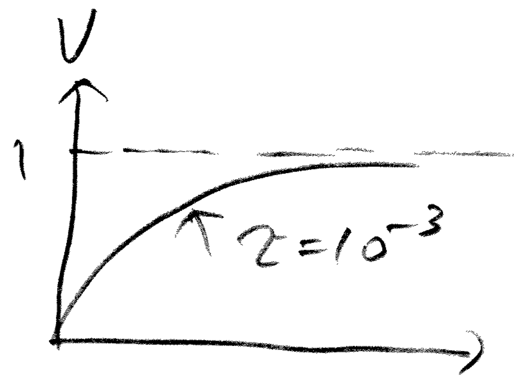
a) $A_v = \dfrac{1}{1+\frac{s}{10^3}}$





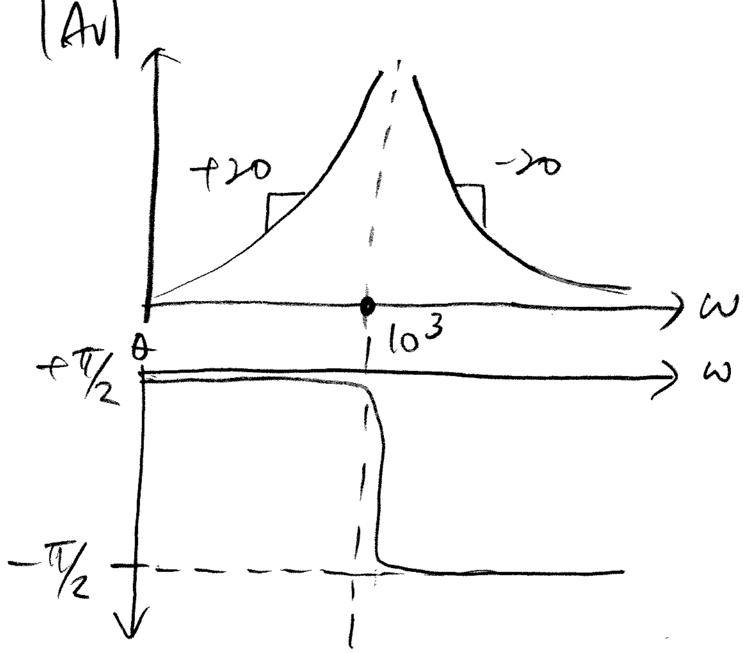
b) $A_v = \dfrac{1}{(1+\frac{s}{10^3})(1+\frac{s}{10^6})}$

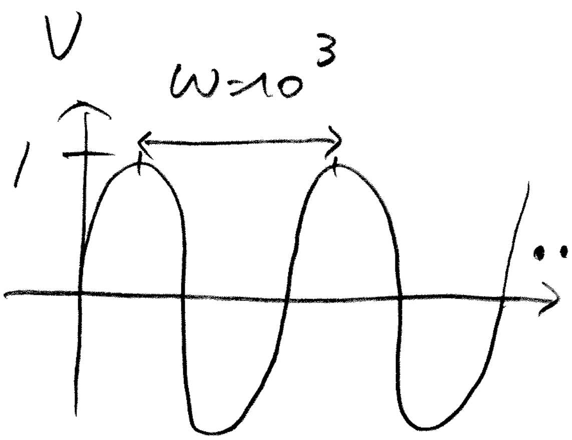




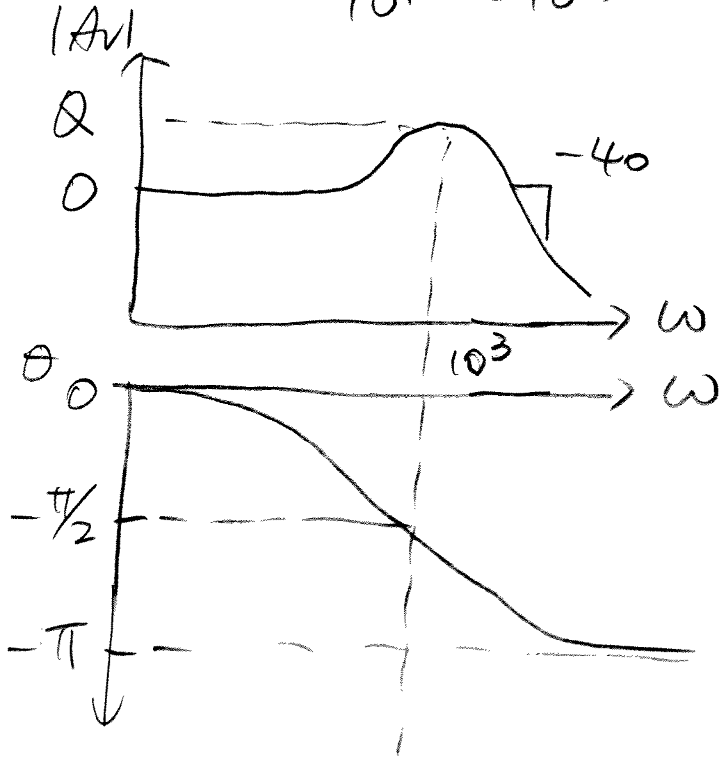
Second time constant $\tau \leq 10^{-6}$ → much faster than 10^{-3}
Approx as 1st order

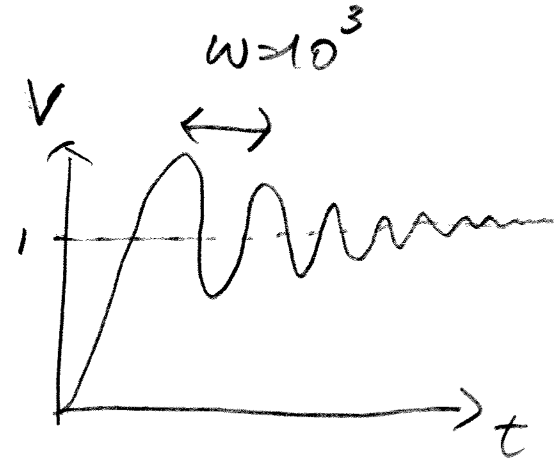
c) $A_v = \dfrac{s/10^3}{1+(s/10^3)^2}$, $Q = \infty$





d) $A_v = \dfrac{1}{1+\frac{s}{10^4}+\left(\frac{s}{10^3}\right)^2}$, $Q = 10$

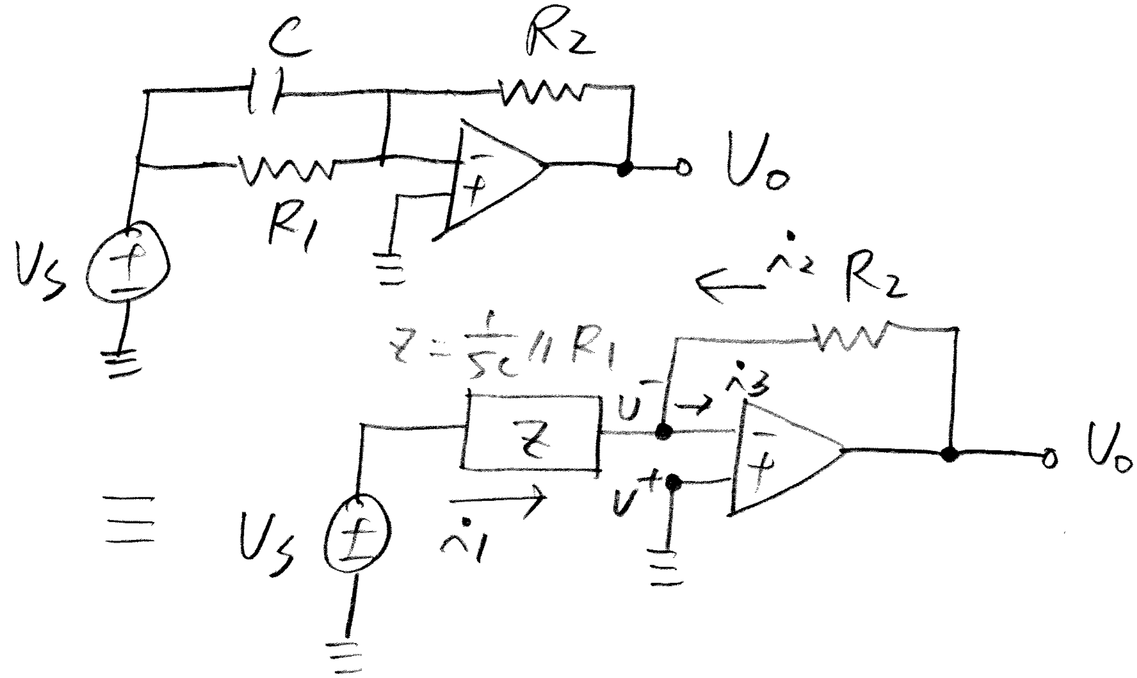




P1.7

a) 11.37

✓



$i_1 + i_2 = i_3$

$\because$ ideal opamps

$\therefore$ $i_3 = 0$, $v^- = v^+ = 0$

$\Rightarrow i_1 = \dfrac{V_s}{\frac{1}{sC} \parallel R_1}$

$i_2 = \dfrac{V_o}{R_2}$

$\because$ $i_1 + i_2 = 0 \Rightarrow i_1 = -i_2$

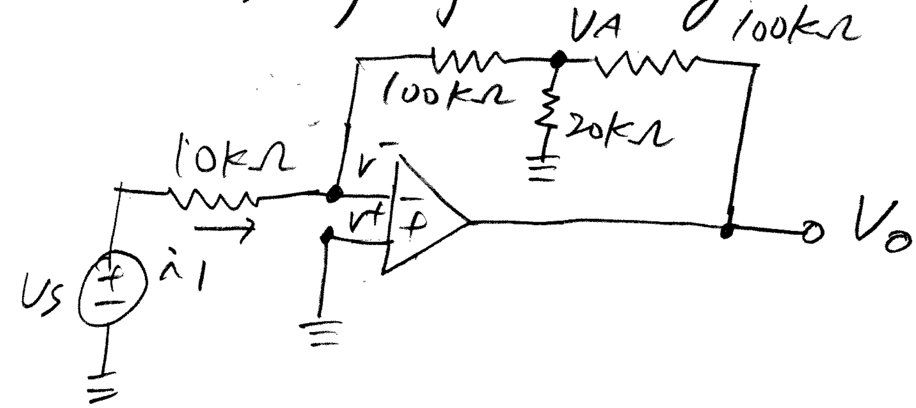
$\therefore$ $\dfrac{V_s}{\frac{1}{sC} \parallel R_1} = -\dfrac{V_o}{R_2}$

$$\Rightarrow \frac{V_o(s)}{V_s(s)} = -\frac{R_2}{\frac{1}{sC} \parallel R_1} = \frac{-R_2}{\frac{\frac{R_1}{sC}}{\frac{1}{sC} + R_1}}$$

$$= -\frac{R_2}{\frac{R_1}{1 + R_1 sC}}$$

$$= \boxed{-\frac{R_2}{R_1}(1 + R_1 sC)}$$ #

b) 11.39 find voltage gain only



∵ ideal opamps ∴ $V^- = V^+ = 0$

$i_1 = \frac{V_s}{10k}$, $V_A = V^- - 100k\, i_1 = -10 V_s$

KCL @ VA :

$$\frac{V_A}{20k} + \frac{(V_A - V_o)}{100k} + \frac{V_A}{100k} = 0$$

$$\Rightarrow \frac{-10V_s}{20k} + \frac{(-10V_s - V_o)}{100k} - \frac{10V_s}{100k} = 0$$

$$\Rightarrow \frac{-V_s}{2k} - \frac{V_s}{10k} - \frac{V_o}{100k} - \frac{V_s}{10k} = 0$$

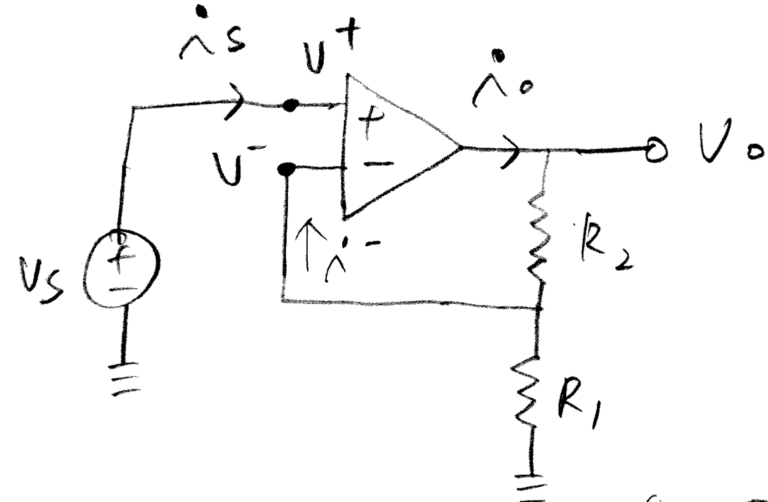
$$\Rightarrow \frac{V_o}{100k} = -\left(\frac{1}{2k} + \frac{1}{10k} + \frac{1}{10k}\right) V_s$$

$$\Rightarrow V_o = -\left(\frac{5+2}{1\cancel{0}\cancel{k}}\right) \times 10\cancel{0}\cancel{k} \times V_s$$

$$\Rightarrow \boxed{\frac{V_o}{V_s} = -70}$$

#

c) 11.42(a) ✓

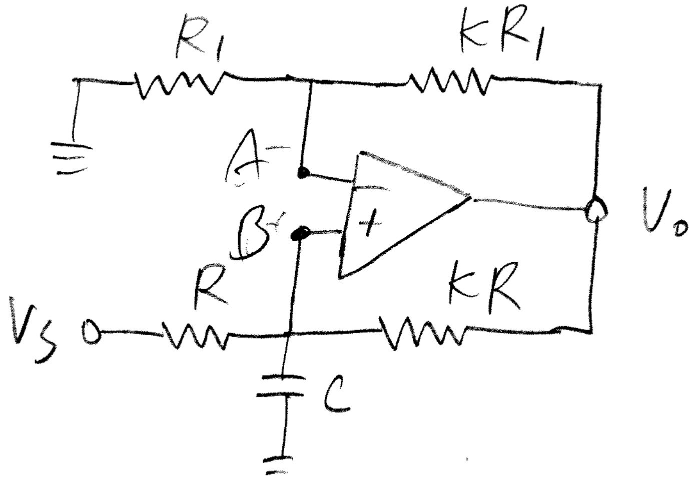


For ideal opamps: $v^+ = v^- = V_s$, $i^- = 0$

$$V_s = \frac{R_1}{R_1+R_2} V_o$$

$$\Rightarrow \boxed{\frac{V_o}{V_s} = \frac{R_1+R_2}{R_1}} \#$$

11.42(b) ✓



$$V_A = V_o \frac{R_1}{R_1 + KR_1}$$

$$= V_o \frac{1}{1+K} = V_B$$

KCL @ B

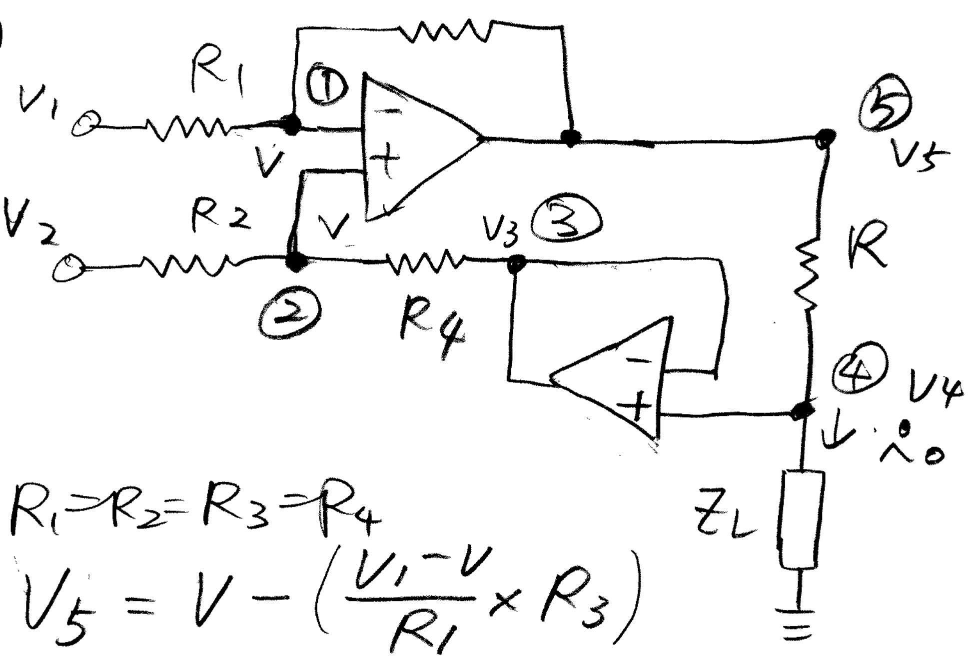
$$\frac{V_B - V_s}{R} + \frac{V_B - V_o}{KR} + \frac{V_B}{\frac{1}{sC}} = 0$$

$$\left(\frac{1}{R} + \frac{1}{KR} + sC\right) V_B - \frac{V_o}{KR} = \frac{V_s}{R}$$

$$\left[\left(\frac{K+1+sCKR}{KR}\right)\left(\frac{1}{1+K}\right) - \frac{1}{KR}\right] V_o = \frac{V_s}{R}$$

$$\Rightarrow \frac{\cancel{K}+\cancel{1}+sC\cancel{K}\cancel{R}-\cancel{1}-\cancel{K}}{\cancel{K}\cancel{R}(1+K)} V_o = \frac{V_s}{R} \Rightarrow \boxed{\frac{V_o}{V_s} = \frac{1+K}{sCR}} \#$$

2) 11.45(a)



$R_1 = R_2 = R_3 = R_4$

$$V_5 = V - \left(\frac{V_1 - V}{R_1} \times R_3\right)$$

$$= \left(1 + \frac{R_3}{R_1}\right)V - \frac{R_3}{R_1}V_1 = 2V - V_1$$

$$V_3 = V_4 = V - \left(\frac{V_2 - V}{R_2} \times R_4\right)$$

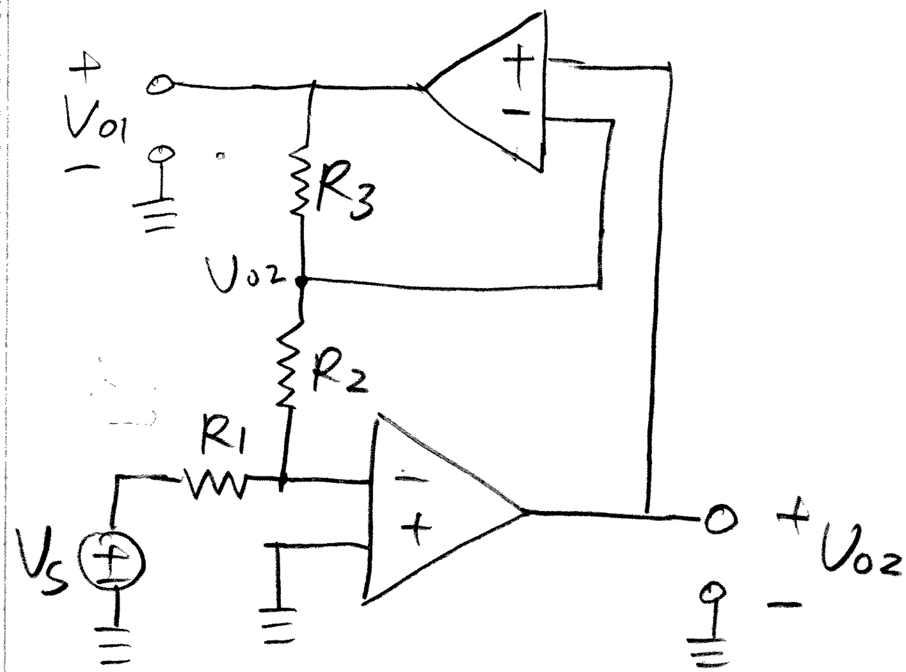
$$= \left(1 + \frac{R_4}{R_2}\right)V - \frac{R_4}{R_2}V_2 = 2V - V_2$$

$$i_o = \frac{V_5 - V_4}{R} = \frac{\cancel{2V} - V_1 - \cancel{2V} + V_2}{R} = \frac{V_2 - V_1}{R}$$

$$\Rightarrow \boxed{i_o = \frac{V_2 - V_1}{R}}$$ #

e) 11.49

V



$$\frac{V_s}{R_1} = \frac{-V_{o2}}{R_2} = \frac{V_{o2} - V_{o1}}{R_3}$$

$$\Rightarrow \boxed{V_{o2} = -\frac{R_2}{R_1} V_s}$$

#

$$\frac{V_s}{R_1} = \frac{-\frac{R_2}{R_1} V_s - V_{o1}}{R_3}$$

$$\Rightarrow V_s = \frac{-R_2 V_s - R_1 V_{o1}}{R_3}$$

$$\Rightarrow -(R_2 + R_3) V_s = -R_1 V_{o1}$$

$$\Rightarrow \boxed{V_{o1} = -\frac{R_2 + R_3}{R_1} V_s}$$

#