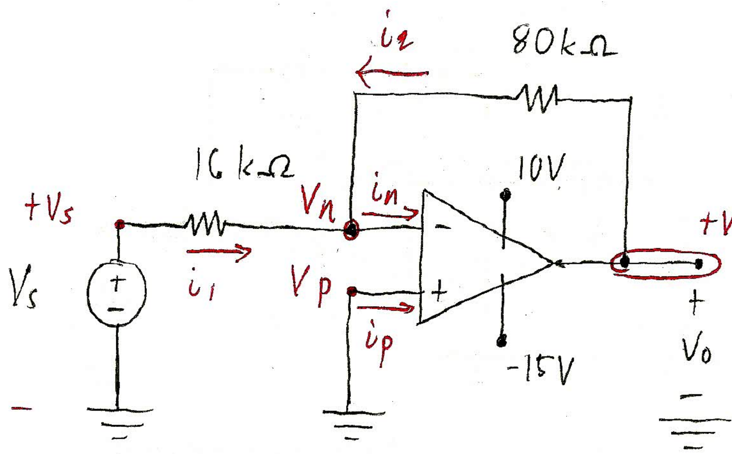
1)



L KCL @ Vn

$i_1 + i_2 - \cancel{i_n}_0 = 0$

$\left[\frac{V_s - V_n}{16} + \frac{V_o - V_n}{80} = 0 \right] 80$

* Votage constraint

$V_n = V_p = 0$

$5V_s - \cancel{5V_n}_0 + V_o - \cancel{V_n}_0 = 0$

$V_o = -5V_s$

L Find Vo

$V_o = -5(0.4) = -2\,V$

$V_o = -5(2.0) = -10\,V$

$V_o = -5(3.5) = -17V$

L Out of range so $V_o = -15V$

$V_o = -5(-0.6) = 3V$

$V_o = -5(-1.6) = 8V$

$V_o = -5(-2.4) = 12V$

L Out of range so $V_o = 10V$

a)

L Let $V_o = 10V$

$10 = -5V_s$

$V_s = -2V$

L Let $V_o = -15V$

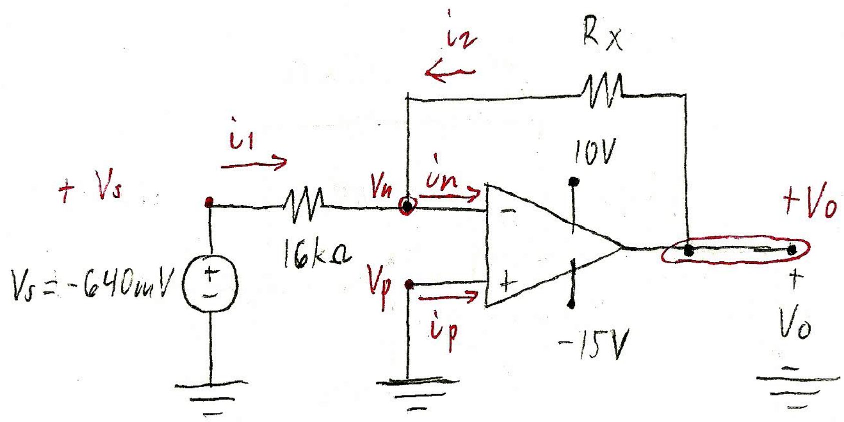
$-15 = -5V_s$

$V_s = 3V$

L To avoid going beyond saturation

$[-2V \leq V_s \leq 3V]$ b)

2)



- KCL @ V_n

$$i_1 + i_2 - \cancel{i_n}^{0} = 0$$

$$\frac{V_s - \cancel{V_n}^{0}}{16000} + \frac{V_o - \cancel{V_n}^{0}}{R_x} = 0 \Rightarrow V_o = -R_x \frac{(-0.64)}{16000}$$

* Voltage constraint

$$V_n = V_p = 0$$

- Let $V_o = 10V$

$$10 = R_x \frac{(0.64)}{16000}$$

$$R_x = 250000\Omega = 250k\Omega$$

- Let $V_o = -15V$

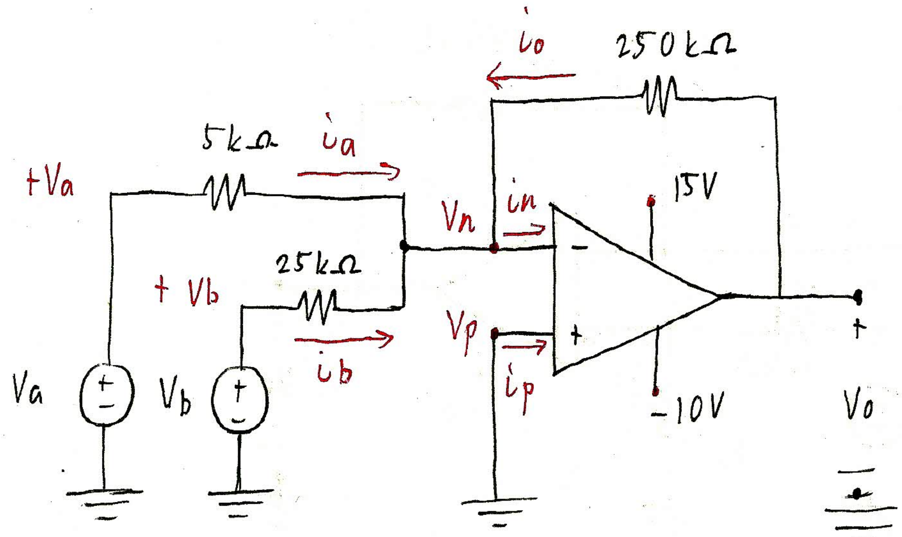
$$-15 = R_x \frac{(0.64)}{16000}$$

* Result is a negative number $R_x \geq 0$

- Range op Resistor R_x

$$[0 \leq R_x \leq 250\ k\Omega]$$

3)



∟ KCL @ Vn

$i_a + i_b + i_o - \cancel{i_n}^{0} = 0$

$\left[\frac{V_a - \cancel{V_n}^{0}}{5000} + \frac{V_b - \cancel{V_n}^{0}}{25000} + \frac{V_o - \cancel{V_n}^{0}}{250000} = 0 \right] 250000$

$50V_a + 10V_b + V_o = 0$

$V_o = -50V_a - 10V_b$

* Voltage Constraint

$V_p = V_n = 0$

∟ Find Vo

$[V_o = -50(0.1) - 10(0.25) = -7.5V]$ a1)

∟ Let $V_b = 0.25V$, $V_o = -10V$

$\left[V_a = \frac{10V - 2.5}{50} = 0.15V \right]$ b1)

, Let $V_b = 0.25V$, $V_o = 15V$

$V_a = \frac{-15 - 2.5}{50} = -0.35V$

∟ Let $V_a = 0.10V$, $V_o = -10V$

$\left[V_b = \frac{10 - 5}{10} = 0.5V \right]$ c1)

∟ Find Vo Let $V_b \Rightarrow -V_b$

$[V_o = -50V_a + 10V_b = -50(0.1) + 10(0.25) = -2.5V]$ a1)

∟ Let $V_b = 0.25V$, $V_o = -10V$, Let $V_b = 0.25V$, $V_o = 15V$

$\left[V_a = \frac{10 + 2.5}{50} = 0.25V \right]$ b2)

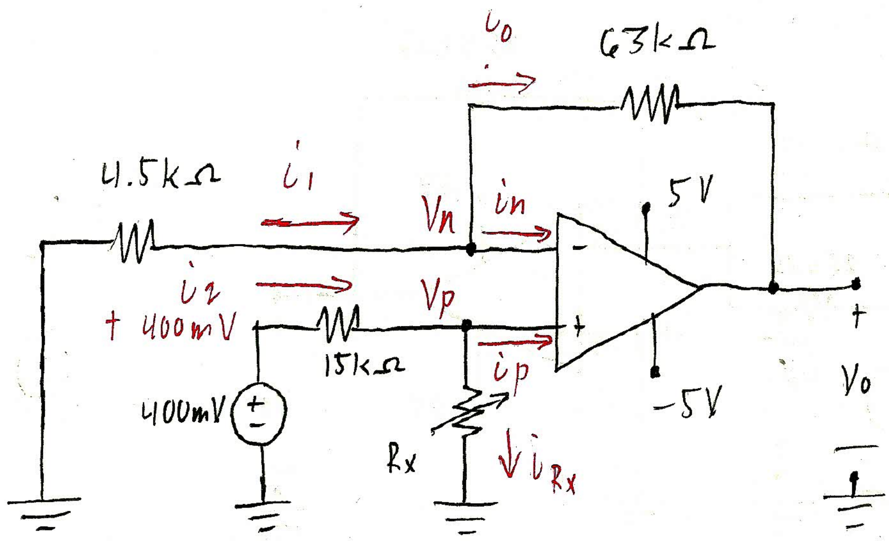
$V_a = \frac{-15 + 2.5}{50} = -0.25$

∟ Let $V_a = 0.10V$, $V_o = -10V$, Let $V_a = 0.10V$, $V_o = 15V$

$V_b = \frac{-10 + 5}{10} = -0.5V$

$\left[V_b = \frac{15 + 5}{10} = 2V \right]$ c2)

4)



L KCL @ V_n

$$i_1 + i_o - \overset{0}{\cancel{i_n}} = 0$$

$$\left[\frac{V_n}{4500} + \frac{V_n - V_o}{63000} = 0\right] 63000$$

$$14V_n + V_n - V_o = 0$$

$$V_o = 15V_n \quad (1)$$

L KCL @ V_p

$$i_2 + i_{Rx} - \overset{0}{\cancel{i_p}} = 0$$

* i_2 and i_{Rx} in series, so $i_{Rx} = i_2$

circuit elements 400mV, 15kΩ, R_x in series

L Use Voltage divider for voltage source, 15kΩ, and R_x = 60kΩ

$$V_p = \frac{R_x}{15000 + R_x}(0.400) = \frac{60000}{15000 + 60000}(0.400) = 0.32\text{ V}$$

L Use (2) in (1) $V_p = V_n = 0.32$V

$$[V_o = 15(0.32) = 4.8\text{ V}] \text{ a)}$$

L Let V_o = 5V

$$5 = 15V_p$$

$$V_p = \frac{5}{15}\text{ V}$$

L Let $V_p = \frac{5}{15}$

$$\frac{5}{15}(15000 + R_x) = R_x(0.400)$$

$$5000 + \frac{5}{15}R_x = R_x(0.400)$$

$$\frac{R_x}{15} = 5000$$

$$[R_x = 75000\,\Omega = 75\text{k}\Omega] \text{ b)}$$

L Let V_o = -5V

$$-5 = 15V_p$$

$$V_p = \frac{-5}{15}$$

L Let $V_p = \frac{-5}{15}$

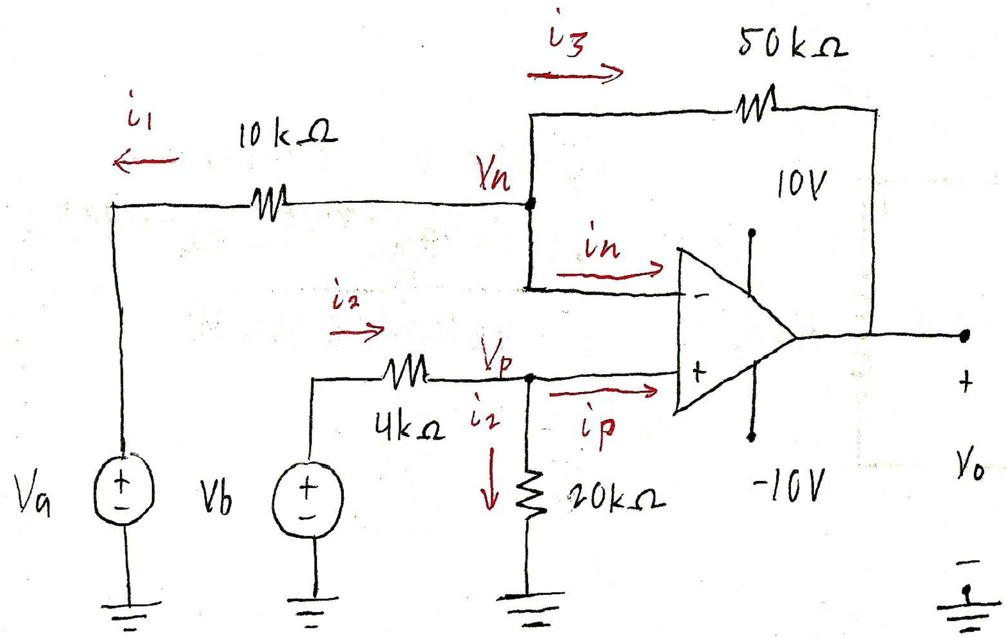
$$\frac{-5}{15}(15000 + R_x) = R_x(0.400)$$

$$-5000 - \frac{5}{15}R_x = R_x(0.400)$$

$$\frac{11}{15}R_x = -5000$$

* R_x can't be negative

5)



L KCL @ Vn

$$i_1 + i_3 + \overset{0}{\cancel{i_n}} = 0$$

$$\left[\frac{V_n - V_a}{10000} + \frac{V_n - V_o}{50000} = 0\right] 50000$$

$$5V_n - 5V_a + V_n - V_o = 0$$

$$V_o = 6V_n - 5V_a \quad (1)$$

L Using Voltage Divider and $V_b = 4.0V$

$$V_p = \frac{20000}{4000 + 20000}(4.0) = \frac{10}{3} = V_n \quad (2)$$

L Use (2) in (1)

$$V_o = 6\left(\frac{10}{3}\right) - 5V_a \Rightarrow V_o = 20 - 5V_a \quad (3)$$

L Let $V_o = 10V$, Let $V_o = -10V$

$10 = 20 - 5V_a$ $\qquad$ $-10 = 20 - 5V_a$

$V_a = 2V$ $\qquad$ $V_a = 6V$

* So $\boxed{2V \le V_a \le 6V}$ a)

L Using Voltage Divider

$$V_p = \frac{8000}{4000 + 8000}(4.0) = \frac{8}{3} = V_n \quad (3)$$

L Use (3) in (1)

$$V_o = 16 - 5V_a$$

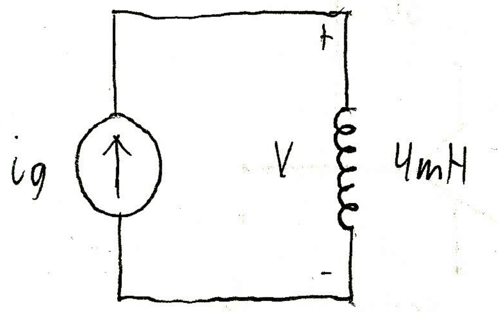
L Let $V_o = 10V$, Let $V_o = -10V$

$10 = 16 - 5V_a$ $\qquad$ $-10 = 16 - 5V_a$

$V_a = 1.2V$ $\qquad$ $V_a = 5.2V$

* so $\boxed{1.2V \le V_a \le 5.2V}$ b)

6)



$i_g(t) = 0 \quad t \leq 0s$

$i_g(t) = 8e^{-300t} - 8e^{-1200t}\,A, \quad t \geq 0s$

$L = 4mH = 0.004\,H$

- Find $\frac{di_g}{dt}$

$$\frac{di_g}{dt} = 8 \cdot \left[e^{-300t}\right] \cdot \frac{d}{dt}\left[-300t\right] - 8 \cdot \left[e^{-1200t}\right] \cdot \frac{d}{dt}\left[-1200t\right]$$

$$\frac{di_g}{dt} = -2400e^{-300t} + 9600e^{-1200t}\ A$$

$$i_g'(0) = -2400 + 9600 = 7200$$

- Find $V = L\frac{di_g}{dt}$

$$\left[V = (7200) \times (0.004) = 28.8V\right] \text{ a)}$$

- Let $V=0$, Find t

$$0.004(2400e^{-300t}) = (9600e^{-1200t})0.004$$

$$\text{Ln}(9.6e^{-300t} = 38.4e^{-1200t})\ \text{Ln}$$

$$\ln(9.6e^{-300t}) = \ln(38.4e^{-1200t})$$

$$-300t + \ln(9.6) = -1200t + \ln(38.4)$$

$$\left[t = \frac{\ln\left(\frac{38.4}{9.6}\right)}{900} = 1.54ms\right] \text{ b)}$$

- Find $p = vi$

$$p = (0.004)(-2400e^{-300t} + 9600e^{-1200t})\left[8e^{-300t} - 8e^{-1200t}\right]$$

$$= \left[-9.6e^{-300t} + 38.4e^{-1200t}\right]\left[8e^{-300t} - 8e^{-1200t}\right]$$

$$= -76.8e^{-600t} + 76.8e^{-1500t} + 307.2^{-1500t} - 307.2e^{-2400t}$$

$$\left[p = -76.8e^{-600t} + 384e^{-1500t} - 307.2e^{-2400t}\right] \text{ c)}$$

L Find $\frac{dp}{dt}$

$$\frac{dp}{dt} = -76.8e^{-600t} + 384e^{-1500t} - 307.2e^{-2400t}$$

$$\frac{dp}{dt} = 46080e^{-600t} - 576000e^{-1500t} + 737280e^{-2400t}$$

L p is maximum when $\frac{dp}{dt} = 0$

$$0 = \left(46080e^{-600t} - 576000e^{-1500t} + 737280e^{-2400t}\right)\frac{1}{46080e^{-2400t}}$$

$$0 = e^{1800t} - 12.5e^{900t} + 16$$

L Let $x = e^{900t}$ and change quadrtic equation in terms of x

$$x^2 - 12.5x + 16 = 0$$

L Find x using quadratic eqution (critical points)

$$x = \frac{12.5 + \sqrt{92.25}}{2}, \quad x = \frac{12.5 - \sqrt{92.25}}{2}$$

$$x = 11.0523, \quad x = 1.4477$$

L By observation, $x = 1.4477$ will give maximum, find t

$$\ln(1.4477) = (e^{900t})\ln$$

$$\ln(1.4477) = 900t$$

$$\left[t = \frac{\ln(1.4477)}{900} = 411.05\ \mu s\right] \text{ d)}$$

L Find P_{max} at $t = 411.05$

$$P_{max} = -76.8e^{-600(411.05)} + 384e^{-1500(411.05)} - 307.2e^{-2400(411.05)}$$

$$\left[P_{max} = 32.72\ W\right] \text{ e)}$$

L We know that W is max when i_g is max, Let $\frac{di_g}{dt} = 0$

$$0 = -2400e^{-300t} + 9600e^{-1200t}$$

$$\left[2400e^{-300t} = 9600e^{-1200t}\right]\frac{1}{2400e^{-300t}}$$

$$1 = 4e^{-900t}$$

$$\ln\left[\frac{1}{4} = e^{-900t}\right]$$

$$\left[t = -\frac{\ln\left(\frac{1}{4}\right)}{900} = 1.54\,ms\right] \text{ f)}$$

L Find i_{max} at $t = 1.54ms$

$$i_{max} = 8e^{-300(1.54)} - 8e^{-1200(1.54)} = 3.78\ A$$

L Find W_{max} with i_{max}

$$\left[W = \frac{1}{2}Li^2 = \left(\frac{1}{2}\right)(0.004)(3.78)^2 = 28.6\ mJ\right] \text{ g)}$$

7)

Given $t = \frac{\pi}{80}$ ms, $C = 0.6\ \mu F = 0.0000006$ F

$V(t) = 0 \quad t < 0s$

$V(t) = 40e^{-15000t} \sin 30000t$ V $\quad t \geq 0s$

L Find $\frac{dV}{dt}$, $i(t) = C\frac{dV}{dt}$

$$C\frac{dV}{dt} = \left[-600000e^{-15000t} \cdot \sin(30000t) + 1200000e^{-15000t}\cos(30000t)\right]0.0000006$$

$$C\frac{dV}{dt} = \left[-0.36\sin(30000t) + 0.72\cos(30000t)\right]e^{-15000t}$$

$$i(0) = \cancel{-0.36\sin(30000(0))}^{0} + 0.72\,\cancel{\cos(30000(0))}^{1}\,\cancel{e^{-15000(0)}}^{1}$$

$[i(0) = 0.72\text{ A}]$ a)

L Find $P = vi$ at $t = \frac{\pi}{80}$ ms $= \frac{\pi}{80} \times 10^{-3}$

$$i\left(\frac{\pi}{80}\right) = \left[-0.36\sin\left(30000\left(\tfrac{\pi}{80}\right)\right) + 0.72\cos\left(30000\left(\tfrac{\pi}{80}\right)\right)\right]e^{-15000\left(\frac{\pi}{80}\right)} = -31.663\text{ mA}$$

$$V\left(\frac{\pi}{80}\right) = 40e^{-15000\left(\frac{\pi}{80}\right)}\sin 30000\left(\tfrac{\pi}{80}\right) = 20.505\text{ V}$$

$[P = -649.23\text{ mW}]$ b)

L Find $w = \frac{1}{2}CV^2$

$\left[w = \frac{1}{2}(0.0000006)(20.505)^2 = 126.13\ \mu J\right]$ c)