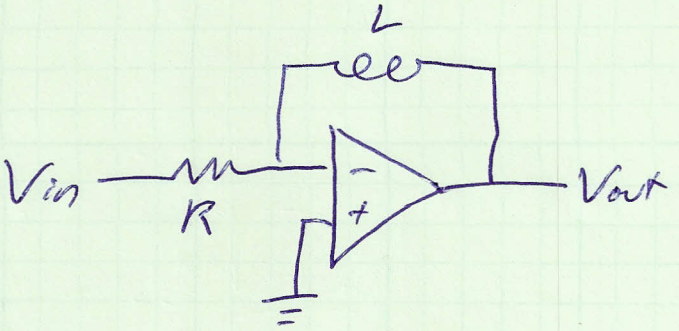
ECE 100 | Fall 2012 | Midterm 2

Question 1

a)



b) $\frac{V_- - V_{in}}{R} + \frac{V_- - V_{out}}{sL} = 0 \qquad V_- = V_+ = 0$

$$\frac{-V_{in}}{R} = \frac{V_{out}}{sL} \rightarrow \boxed{\frac{V_{out}}{V_{in}} = \frac{-sL}{R}}$$ differentiator

note, $\frac{df(t)}{dt} \longleftrightarrow sF(s) - f(0)$

c) $\frac{V_- - V_{in}}{R} + \frac{V_- - V_{out}}{sL} = 0$, $V_{out} = A(V_+ - V_-) \rightarrow V_- = \frac{-V_{out}}{A}$

$$\frac{\frac{-V_{out}}{A} - V_{in}}{R} + \frac{\frac{-V_{out}}{A} - V_{out}}{sL} = 0$$

$$V_{out}\left(\frac{sL}{R}\right) + AV_{in}\left(\frac{sL}{R}\right) + V_{out}(1+A) = 0$$

$$V_{out}\left(1 + A + \frac{sL}{R}\right) = -AV_{in}\left(\frac{sL}{R}\right)$$

$$\frac{V_{out}}{V_{in}} = \frac{-sL}{R}\left(\frac{A}{1+A+\frac{sL}{R}}\right) = \frac{-sL}{R}\left(\frac{G/s}{1+G/s+sL/R}\right)$$

$$\boxed{\frac{V_{out}}{V_{in}} = \frac{-sL}{R} \cdot \left(\frac{1}{1+s/G+s^2L/GR}\right)}$$

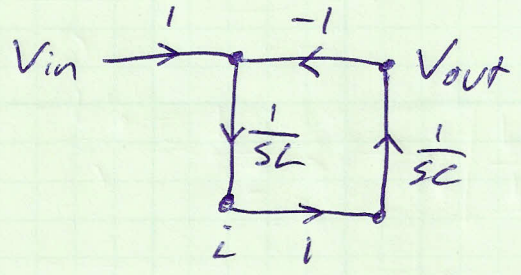
second order

Question 2

a) $i = \dfrac{V_{in} - V_{out}}{sL}$

$$V_{out} = \frac{i}{sC}$$

b)



c) $\Delta = 1 + \dfrac{1}{s^2LC}$

forward path $= \dfrac{1}{s^2LC}$

$$\frac{V_{out}}{V_{in}} = \frac{\frac{1}{s^2LC}}{1 + \frac{1}{s^2LC}}$$

$$\boxed{\frac{V_{out}}{V_{in}} = \frac{1}{1 + s^2LC}}$$

Question 3

a) $V_- = V_{out} \cdot \frac{1 - s\tau/2}{1 + s\tau/2}$

$$V_{out} = A(V_+ - V_-) = A\left(V_{in} - V_{out}\frac{1 - s\tau/2}{1 + s\tau/2}\right)$$

$$V_{out}\left(1 + A\frac{1 - s\tau/2}{1 + s\tau/2}\right) = A V_{in}$$

$$\boxed{\frac{V_{out}}{V_{in}} = \frac{A}{1 + A\frac{1 - s\tau/2}{1 + s\tau/2}}}$$ or $\frac{V_{out}}{V_{in}} = \frac{1 + s\tau/2}{1 - s\tau/2}$ okay too (ideal opamp)

b) $A = G/s \rightarrow \frac{V_{out}}{V_{in}} = \frac{G/s}{1 + \frac{G}{s}\cdot\frac{1 - s\tau/2}{1 + s\tau/2}}$

$$\frac{V_{out}}{V_{in}} = \frac{1 + s\tau/2}{\frac{s}{G}(1 + s\tau/2) + 1 - s\tau/2}$$

$$\boxed{\frac{V_{out}}{V_{in}} = \frac{1 + s\tau/2}{1 + s\left(\frac{1}{G} - \frac{\tau}{2}\right) + \frac{s^2\tau}{2G}}}$$ second order

c) unstable when s is negative

$$\frac{1}{G} - \frac{\tau}{2} < 0$$

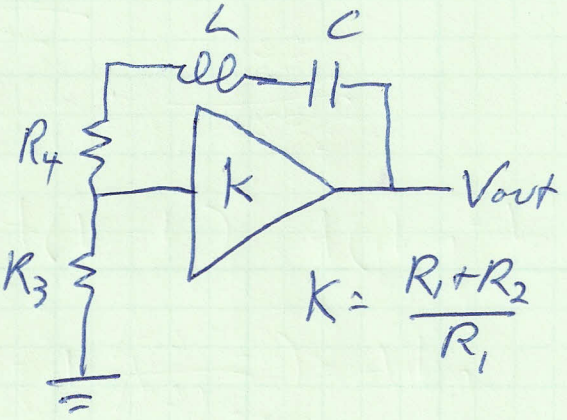
$$\tau > \frac{2}{G}$$

for $G = 10^5$ rad/sec

unstable when $\tau > 2\times10^{-5}$ sec

Question 4

a)



$$K = \frac{R_1+R_2}{R_1}$$

b) $$V_{in} = V_{out} \cdot \frac{R_3}{R_3+R_4+sL+\frac{1}{sC}}$$

$$AB = \frac{-KR_3}{R_3+R_4+sL+\frac{1}{sC}} = \frac{-(R_1+R_2)\frac{R_3}{R_1}}{R_3+R_4+sL+\frac{1}{sC}}$$

c) oscillator when $AB = -1$

$$AB = \frac{-sC(R_1+R_2)\frac{R_3}{R_1}}{1+sC(R_3+R_4)+s^2LC}$$

resonant frequency $\omega_0 = \frac{1}{\sqrt{LC}}$

for $s = j\omega_0$

$$AB = \frac{-j\omega_0 C(R_1+R_2)\frac{R_3}{R_1}}{1+j\omega_0 C(R_3+R_4)-1}$$

$$\frac{-(R_1+R_2)\frac{R_3}{R_1}}{R_3+R_4} = -1 \quad \text{for oscillator}$$

$$\boxed{(R_1+R_2)R_3 = (R_3+R_4)R_1}$$