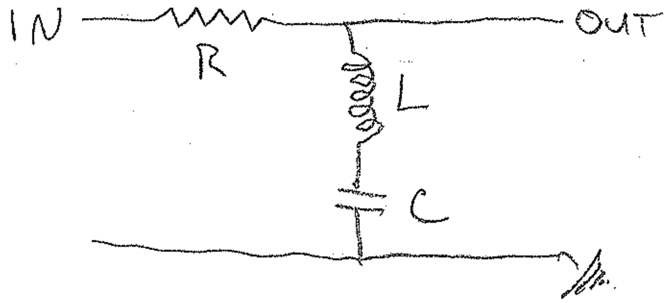
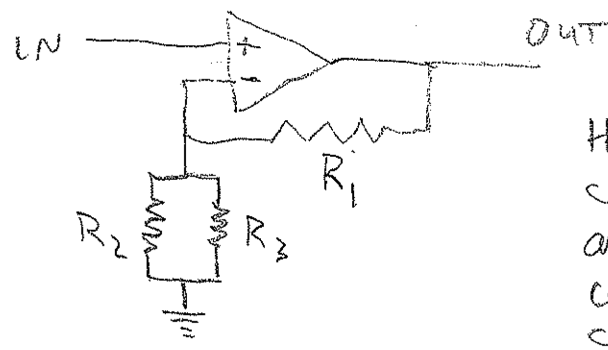
PHYSICS 364, 2010-10-04 QUIZ #3

(1) Derive an expression for V_{OUT}, assuming $V_{IN} = \mathrm{Re}\{V_I e^{j\omega t}\}$.



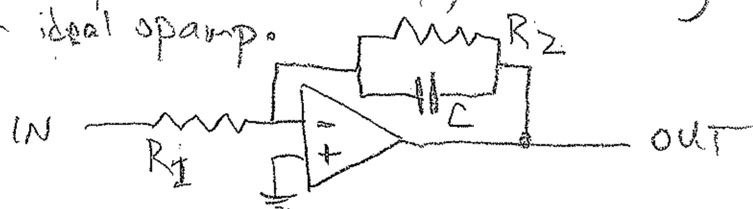
At what frequency $f \equiv \omega/2\pi$ does $V_{OUT} = 0$?

(2) Assuming an ideal opamp, calculate V_{OUT}/V_{IN}.



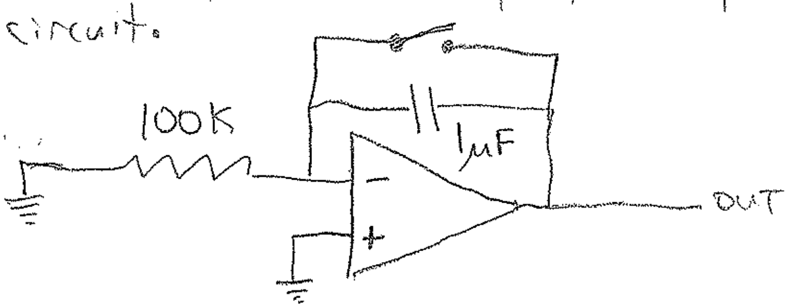
How does your expression change if R_1, R_2, and R_3 are replaced by simple combinations of resistors, capacitors, and inductors ?

(3) Derive an expression for V_{OUT}, assuming $V_{IN} = \mathrm{Re}\{V_I e^{j\omega t}\}$. Assume an ideal opamp.



(4) For a typical real-life opamp such as the '741, what happens when the switch is opened (i.e. made non-conducting)? Assume that the switch was initially in the closed (conducting) state. Note the two most relevant opamp imperfections for this circuit.

What would an ideal opamp do?



QUIZ #3 SOLUTIONS

PHYSICS 364
2010-10-04

① $\frac{V_{OUT}}{V_{IN}} = \frac{j\omega L + 1/j\omega C}{R + j\omega L + 1/j\omega C} = \frac{1-\omega^2 LC}{1-\omega^2 LC + j\omega RC}$

$V_{OUT} = \mathrm{Re}\left\{ \frac{1-\omega^2 LC}{1-\omega^2 LC + j\omega RC} \cdot V_I e^{j\omega t} \right\}$

$V_{OUT} = 0$ for $f = \frac{1}{2\pi\sqrt{LC}}$

② $\frac{V_{OUT}}{V_{IN}} = 1 + \frac{R_1}{R_2 // R_3}$

in more general case, $\frac{V_{OUT}}{V_{IN}} = 1 + \frac{Z_1}{Z_2 // Z_3}$

where $Z = R,\ j\omega L,\ \frac{1}{j\omega C}$, etc.

③ $\frac{V_{OUT}}{V_{IN}} = -\frac{R_2 // \frac{1}{j\omega C}}{R_1} = -\frac{R_2}{R_1 \cdot (1 + j\omega R_2 C)}$

$V_{OUT} = \mathrm{Re}\left\{ -\frac{R_2/R_1}{1 + j\omega R_2 C} \cdot V_I e^{j\omega t} \right\}$

④ V_{OUT} would saturate at $\pm V_{supply}$ within seconds, because

① V_{offset} looks to the opamp as if the (+) input were ± a few mV

② Bias current of $\mathcal{O}(100\,nA)$ has no effect on (+) but through R has same effect on (−) as an input voltage of $I_{BIAS} \cdot R \simeq \mathcal{O}(10\,mV)$.

For an ideal opamp, $V_{OUT} = 0$ and stays there, assuming capacitor $Q_0 = 0$ (as assured by the switch).