Reading List
Chapter 14.4, 14.7, 14.8, 14.9 of Hambley textbook
Chapter 3 of Hambley textbook

P1. (Hambley 14.23) Output Impedance of Op-Amp Circuits
Analyze each of the ideal op-amp circuits shown in the figure below to find expressions for $i_0$. What is the value of the output impedance for each of these circuits? Why?
(Note: the bottom end of the input voltage source is not grounded in part b of the figure. Thus, we say this source is floating)

\[ \text{Fig.1 Circuit schematics for problem 1.} \]

P2. (Hambley 14.30) Gain Tolerance
Suppose that we design an inverting amplifier using 5% tolerance resistors and an ideal op-amp. The nominal amplifier gain is -2. What are the minimum and maximum gain possible, assuming the resistors are within the stated tolerance? What is the percentage tolerance of the gain? (Gain tolerance % = 100*(GainMax-GainMin)/(GainNominal))

P3. (Hambley P14.34) Two Op-Amp Circuits in Tandem
The circuit shown in the figure below employs negative feedback. Use the summing point constraint for both amps to derive expressions for the voltage gains $A_1 = \frac{V_{o1}}{V_{in}}$; $A_2 = \frac{V_{o2}}{V_{in}}$.

![Fig.2 Circuit Schematic for Problem 3](image)

**P4. (Hambley 14.48) Analysis with full Op-Amp Model**

The objective of this problem is to investigate the effects of finite gain, finite input impedance, and non-zero output impedance of the op-amp on the inverting amplifier. The circuit, including the op-amp model, is shown in the figure below.

A. Derive an expression for the circuit voltage gain $v_o/v_s$. Evaluate for $A_{OL} = 10^5$, $R_{in} = 1M$ Ohm, $R_o = 25$ Ohm, $R_1 = 1K$ Ohm, $R_2 = 10K$ Ohm. Compare this results to the gain with an ideal op-amp.

B. Derive an expression for the circuit input impedance $Z_{in} = v_s/i_s$. Evaluate for $A_{OL} = 10^5$, $R_{in} = 1M$ Ohm, $R_o = 25$ Ohm, $R_1 = 1K$ Ohm, $R_2 = 10K$ Ohm. Compare this results to the input impedance with an ideal op-amp.

C. Derive an expression for the circuit output impedance $Z_o = v_o/i_o$. Evaluate for $A_{OL} = 10^5$, $R_{in} = 1M$ Ohm, $R_o = 25$ Ohm, $R_1 = 1K$ Ohm, $R_2 = 10K$ Ohm. Compare this results to the output impedance with an ideal op-amp.
P5 (Hambley 3.25) Capacitors in Series and in Parallel
Find the equivalent capacitance between terminals X and Y for each of the circuits shown in the figure

![Circuit Schematic for Problem 4](image)

P6. (Hambley 3.28) Capacitors Charging Behavior
Two initially uncharged capacitors $C_1=15\mu F$ and $C_2=10\mu F$ are connected in series. Then, a 10V source is connected to the series combination, as shown in the figure below. Find the voltages $v_1$ and $v_2$ after the source is applied. (Hint: the charges stored on the two capacitors must be equal because the current is the same in both capacitors)
**P7 (Hambley 3.48) Inductor Behavior**

The voltage across a 2H inductance is shown in the figure below. The initial current in the inductance is $i(0)=0$. Sketch the current, power, and stored energy to scale versus time.

**P8. (Hambley 14.75) Differentiator**

Sketch the output voltage of the ideal op-amp circuit shown in the figure below to scale versus time.
Fig. 7 Circuit Schematic for Problem 8