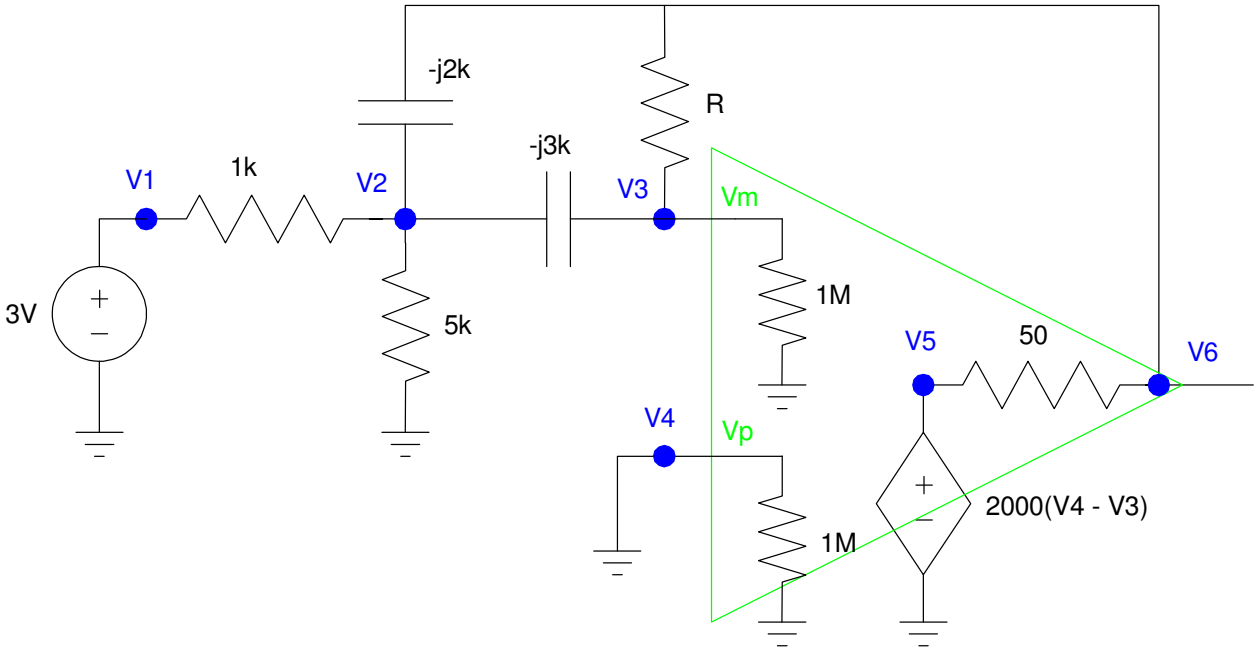
ECE 321 - Quiz #1 - Name _____

Op-Amp Amplifiers & mixers. Due midnight, April 9th
Open-Book. Open Notes. Calculators, Matlab permitted.

1) Non-Ideal Op Amp: Write the voltage node equations for V1..V5. You don't need to solve

- Assume R = 1000 + 100*(your birth month) + (your birth day). For example, May 14th gives R = 1514.



$$V_1 = 3$$

$$\left(\frac{V_2-V_1}{1k}\right)+\left(\frac{V_2-V_6}{-j2k}\right)+\left(\frac{V_2-V_3}{-j3k}\right)+\left(\frac{V_2}{5k}\right)=0$$

$$\left(\frac{V_3-V_2}{-j3k}\right)+\left(\frac{V_3-V_6}{R}\right)+\left(\frac{V_3}{1M}\right)=0$$

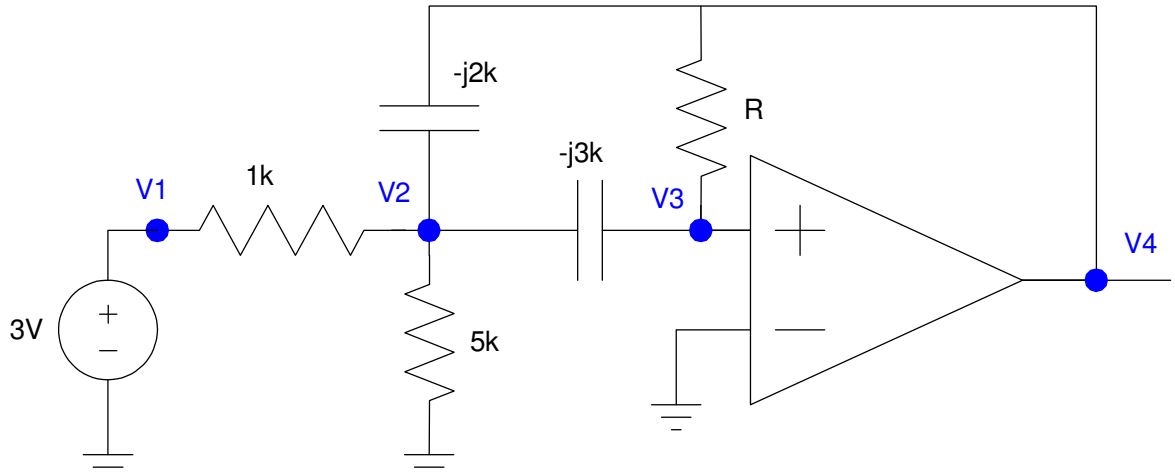
$$V_4 = 0$$

$$V_5 = 2000(V_4 - V_3)$$

$$\left(\frac{V_6-V_2}{-j2k}\right)+\left(\frac{V_6-V_3}{R}\right)+\left(\frac{V_6-V_5}{50}\right)=0$$

2) Ideal Op-Amp. Give 4 equations which allow you to solve for the four unknown voltages. You do not need to solve.

- Assume ideal op-amps.
- Assume R = 1000 + 100*(your birth month) + (your birth day). For example, May 14th gives R = 1514.



$$V_1 = 3$$

$$\left(\frac{V_2 - V_1}{1k}\right) + \left(\frac{V_2 - V_6}{-j2k}\right) + \left(\frac{V_2 - V_3}{-j3k}\right) + \left(\frac{V_2}{5k}\right) = 0$$

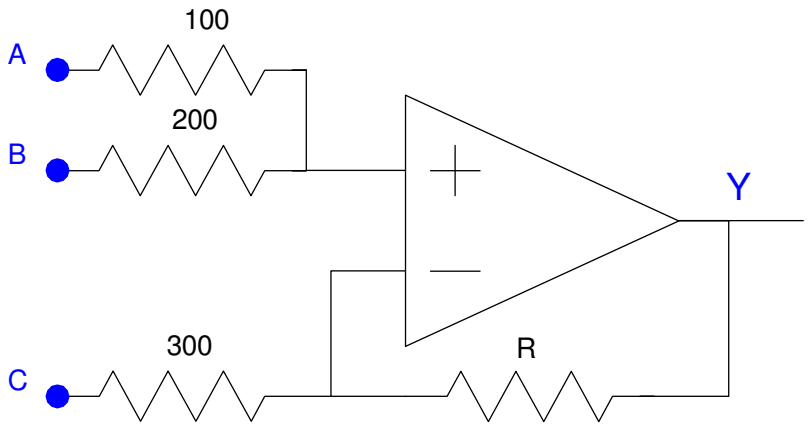
$$\left(\frac{V_3 - V_2}{-j3k}\right) + \left(\frac{V_3 - V_6}{R}\right) + \left(\frac{V_3}{1M}\right) = 0$$

(Vp = Vm)

$$V_3 = 0$$

3) Determine Y as a funciton of A, B, and C.

- Assume ideal op-amps
- Assume R = 1000 + 100*(your birth month) + (your birth day). For example, May 14th gives R = 1514.



By superposition: B = C = 0

$$V_p = \left(\frac{2}{3}\right)A$$

$$Y = \left(1 + \frac{R}{300}\right)V_p = \left(1 + \frac{R}{300}\right)\left(\frac{2}{3}\right)A$$

A = C = 0

$$V_p = \left(\frac{1}{3}\right)B$$

$$Y = \left(1 + \frac{R}{300}\right)\left(\frac{1}{3}\right)B$$

A = B = 0

$$Y = -\left(\frac{R}{300}\right)C$$

By superposition

$$Y = \left(1 + \frac{R}{300}\right)\left(\frac{2}{3}\right)A + \left(1 + \frac{R}{300}\right)\left(\frac{1}{3}\right)B - \left(\frac{R}{300}\right)C$$

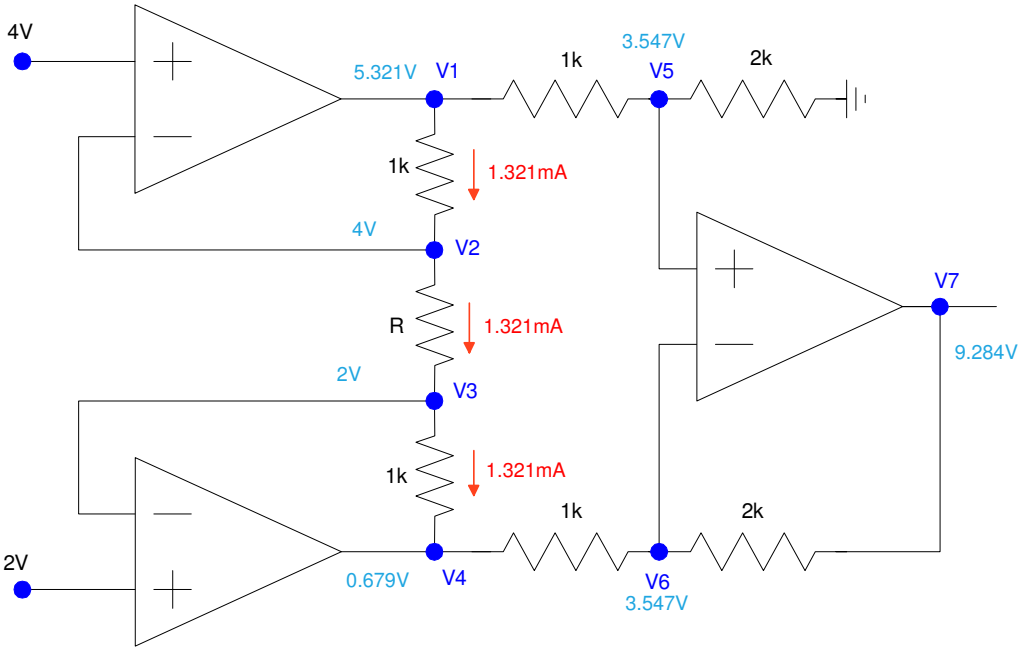
R = 1514 Ohms

$$Y = 4.0311A + 2.0156B - 5.0467C$$

4) Determine the voltages V1..V7 for the following circuit.

- Assume ideal op-amps.
- Assume R = 1000 + 100*(your birth month) + (your birth day). For example, May 14th gives R = 1514.

V1	V2	V3	V4	V5	V6	V7
5.321V	**4V**	**2V**	**0.679V**	**3.547V**	**3.547V**	**9.294V**



With negative feedback, Vp = Vm

- V2 = 4V
- V3 = 2V
- V5 = V6

The current from V2 to V3 is

$$I = \left(\frac{4V-2V}{1514}\right) = 1.321mA$$

$$V_1 = V_2 + 1k \cdot I = 5.321V$$

$$V_4 = 2 - 1k \cdot I = 0.679V$$

$$V_5 = \left(\frac{2}{3}\right) V_1 = 3.547V$$

To find V7, two approaches

$$\left(\frac{V_6-V_4}{1k}\right) + \left(\frac{V_6-V_7}{2k}\right) = 0$$

or note that the last stage is an instrumentation amplifier with a gain of 2

$$V_7 = 2(V_1 - V_4)$$

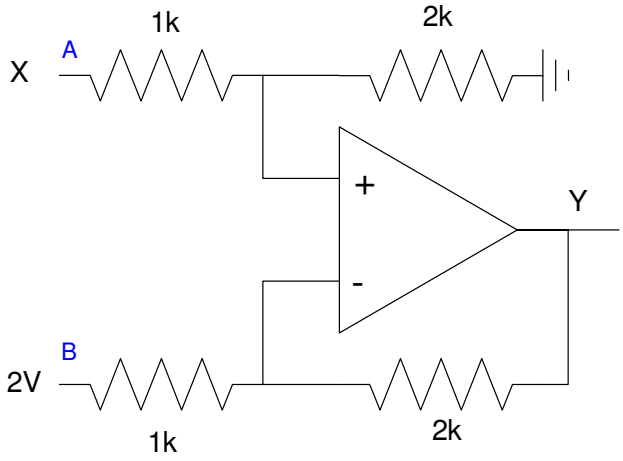
5) Design a circuit to implement

Y = 2X - 4

Many solutions. If you use an instrumentation amplifier, rewrite as

$$Y = 2(X - 2)$$

$$Y = \left(\frac{R_1}{R_2}\right)(A - B)$$

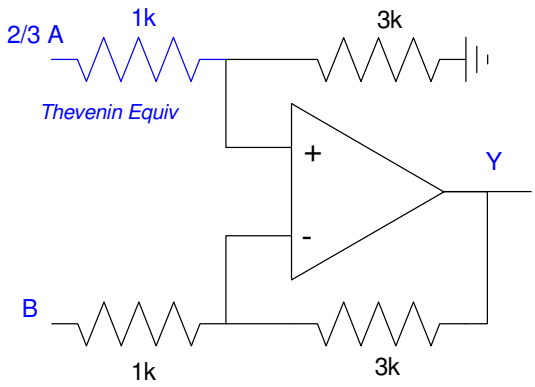


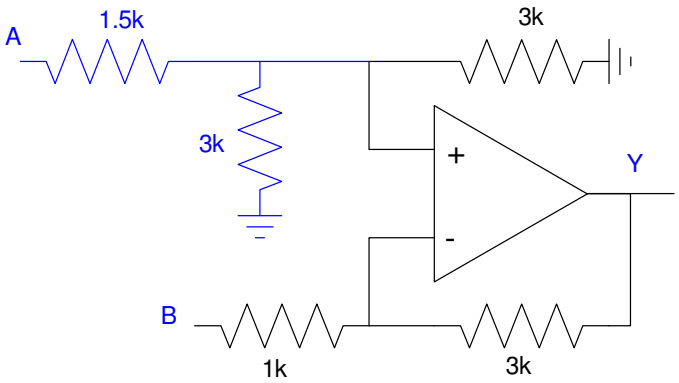
6) Design a circuit to implement

Y = 2A - 3B

There are many solutions. Using an instrumentation amplifier

$$Y = 3\left(\tfrac{2}{3}A - B\right)$$





Using inverting amlfiers