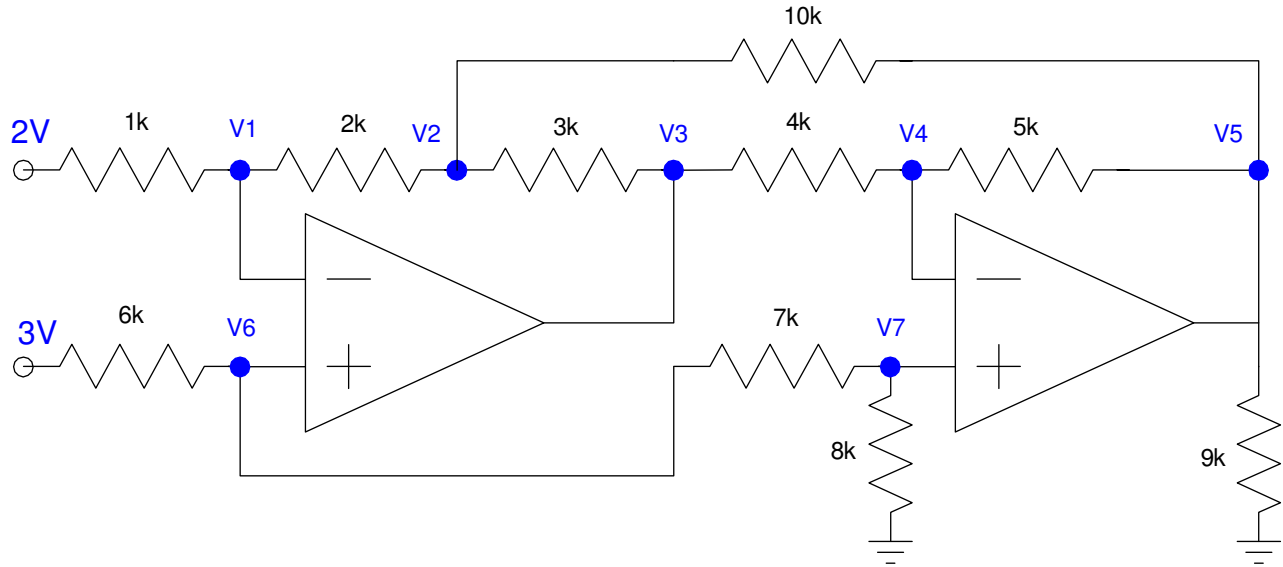Op-Amp Amplifiers & mixers., Push-Pull Amplifiers - Spring 2023

1) Give 7 equations which allow you to solve for the 7 unknown voltages. You do not need to solve.

- Assume ideal op-amps.

Start with the easy ones: Vp = Vm

$$V_1 = V_6$$

$$V_4 = V_7$$

Now do the rest of the node equations

$$\left(\frac{V_1-2}{1k}\right) + \left(\frac{V_1-V_2}{2k}\right) = 0$$

$$\left(\frac{V_2-V_1}{2k}\right) + \left(\frac{V_2-V_3}{3k}\right) + \left(\frac{V_2-V_5}{10k}\right) = 0$$
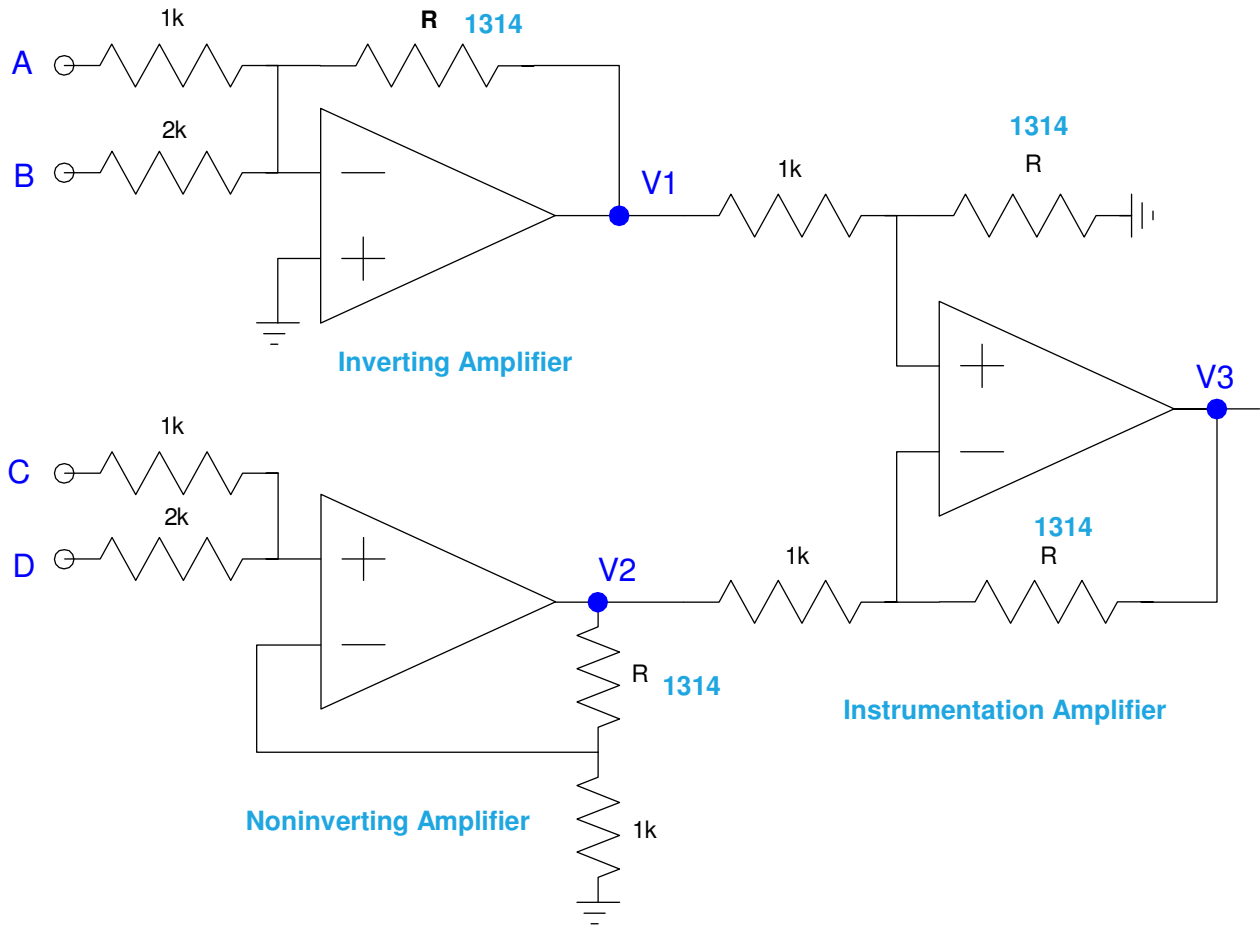
$$\left(\frac{V_4-V_3}{4k}\right) + \left(\frac{V_4-V_5}{5k}\right) = 0$$

$$\left(\frac{V_6-3}{6k}\right) + \left(\frac{V_6-V_7}{7k}\right) = 0$$

$$\left(\frac{V_7-V_6}{7k}\right) + \left(\frac{V_7}{8k}\right) = 0$$

2) Determine V1, V2, and V3 as a funciton of A, B, C, and D.
- Assume ideal op-amps
- Assume R = 800 + 100*(your birth month) + (your birth day).

$$V_1 = -\left(\frac{1314}{1k}\right)A - \left(\frac{1314}{2k}\right)B$$

$$V_2 = \left(1 + \frac{1314}{1k}\right)\left(\frac{2C+D}{3}\right)$$

$$V_3 = \left(\frac{1314}{1k}\right)(V_1 - V_2)$$
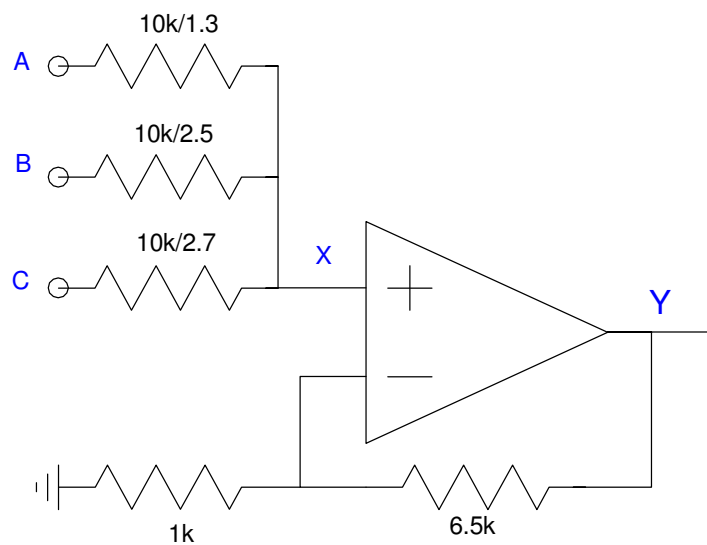
3) Design a circuit which outputs

$$Y = 1.3A + 2.5B + 3.7C$$

note: the gain on A and B are positive

Add a dummy variable

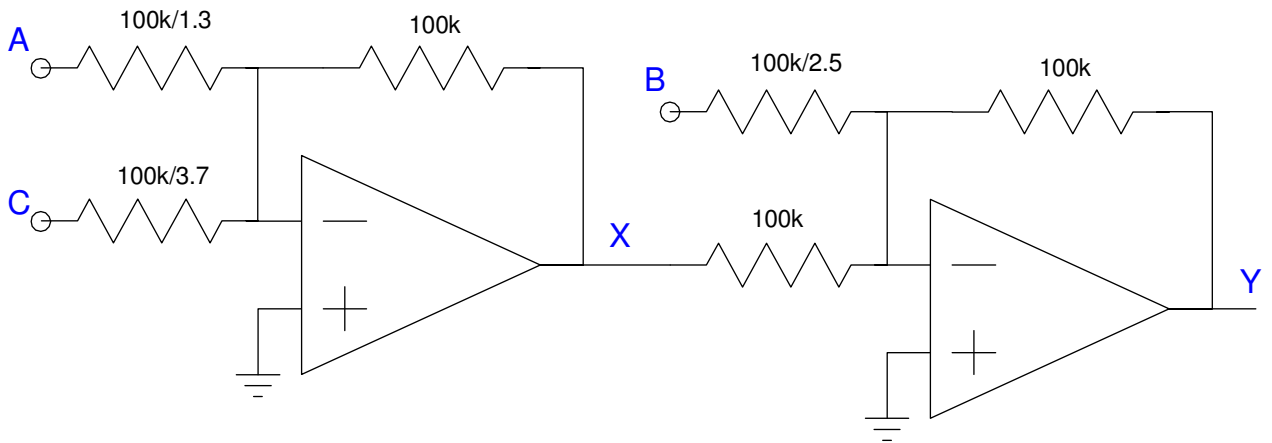$$X = \left(\frac{1.3A + 2.5B + 3.7C}{7.5} \right)$$

$$Y = 7.5X$$

10k/1.3

A

10k/2.5

B

10k/2.7

C

X

+

−

Y

1k

6.5k

4) Design a circuit which outputs

$$Y = 1.3A - 2.5B + 3.7C$$

note: the gain on B is negative

A — 100k/1.3 —|
       100k
C — 100k/3.7 —|—[−/+ op-amp]— X — 100k —|[−/+ op-amp]— Y
B — 100k/2.5 —| 100k

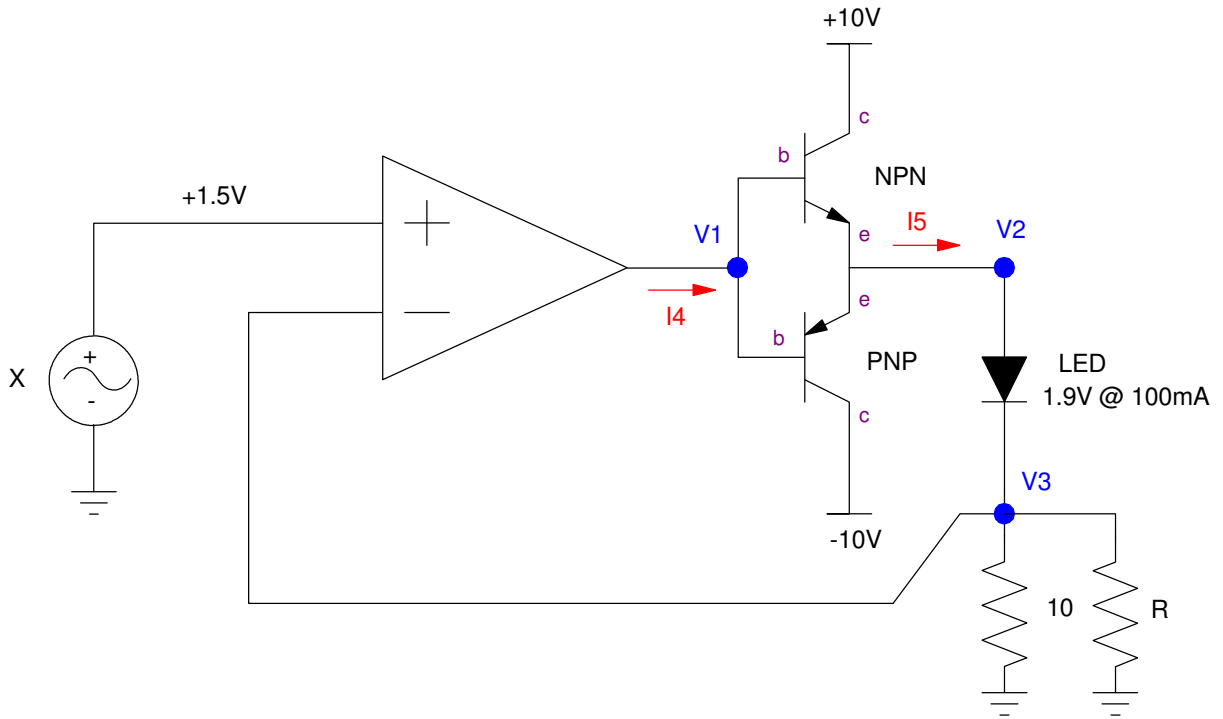5) Determine the voltages and currents for the following push-pull amlifier. Assume
   - Ideal op-amps
   - X = 1.5VDC
   - R = 800 + 100*(your birth month) + (your birth day)
   - Transistors with:
     - $\beta = 25$
     - $|V_{be}| = 0.7V$

+15V

c

b

NPN

+1.5V

V1

I5

V2

e

I4

e

b

PNP

X

c

R

8

V3

-15V

1k
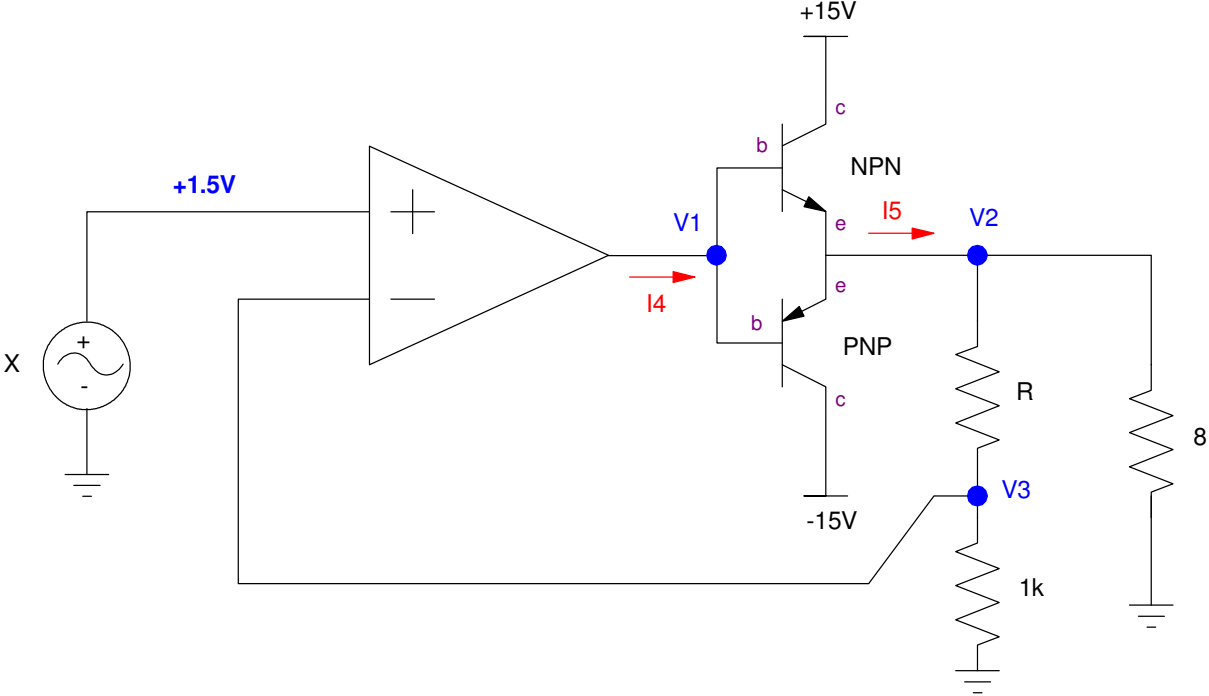
R 800 + 100*mo + day	V1	V2	V3	I4	I5
1314	**4.171V**	**3.471V**	**1.5V**	**16.5mA**	**428.6mA**
	V2 + 0.7V	V3 * (1 + R/1k)	Vp = Vm	I5 / 26	

6) Determine the voltages and currents for the following push-pull amlifier. Assume
   - Ideal op-amps
   - X = 1.5VDC
   - R = 800 + 100*(your birth month) + (your birth day)
   - Transistors with
     - β = 25
     - $|V_{be}| = 0.7V$

R	V1	V2	V3	I4	I5
800 + 100*mo + day					
1314	4.1V	3.4V	1.5V	5.8mA	151.1mA
	V2 + 0.7V	V3 + 1.9V	Vp = Vm	I5 / 26	