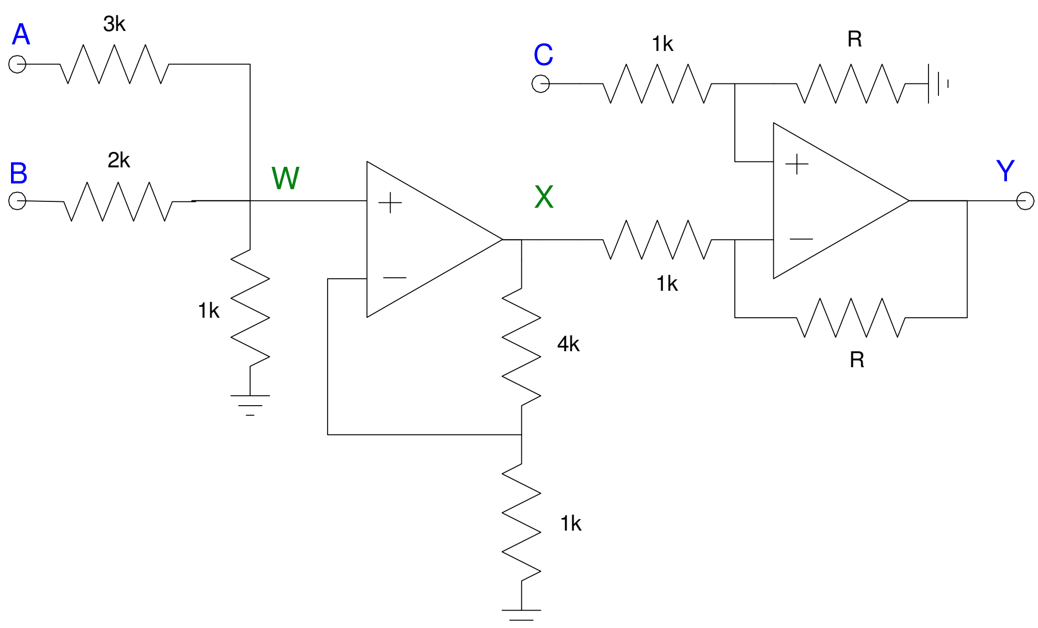
ECE 321 - Final Exam - Name ____________________

Fall 2021

1. OpAmp Circuits: Determine y as a function of A, B, and C. Assume

- Ideal op-amps
- R 1100 + 100*(your birth month) + (your birth day). May 14th would give R = 1614 Ohms

R 1100 + 100*mo + day	Y = aA + bB + cC
1614	**Y = - 1.345A - 2.0175B + 1.614C**



W is a weighted average. Picking the least-common multiple (6k)

$$W = \left(\frac{2A+3B+6\cdot 0}{12}\right) = \left(\frac{1}{6}\right)A + \left(\frac{1}{4}\right)B$$

$$X = 5W$$

$$Y = 1.614(C - X)$$

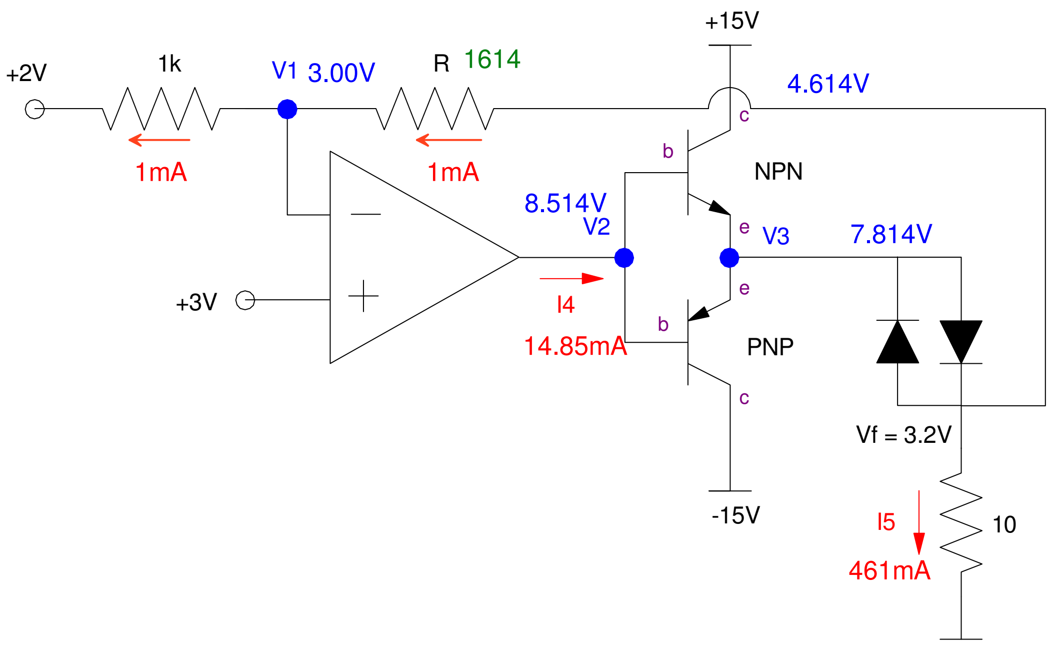
Putting it all together

$$Y = 1.614C - 1.345A - 2.0175B$$

2. Push-Pull: Determine the voltages and currents for the following push-pull amplifier. Assume

- R = 1100 + 100*(birth month) + (birth day). May 14th gives R = 1614 Ohms
- | Vce | = 0.7V (ideal silicon diodes)
- $\beta = 30$

R 1100 + 100*mo + day	V1	V2	V3	I4	I5
1614	**3.00V**	**8.514V** V3 + 0.7	**7.814V** varies with R	**14.85mA** (I5 + 1mA)/31	**461mA**



3. Instrumentation Amplifier: Assume a thermistor has the temperature - resistance relationship of

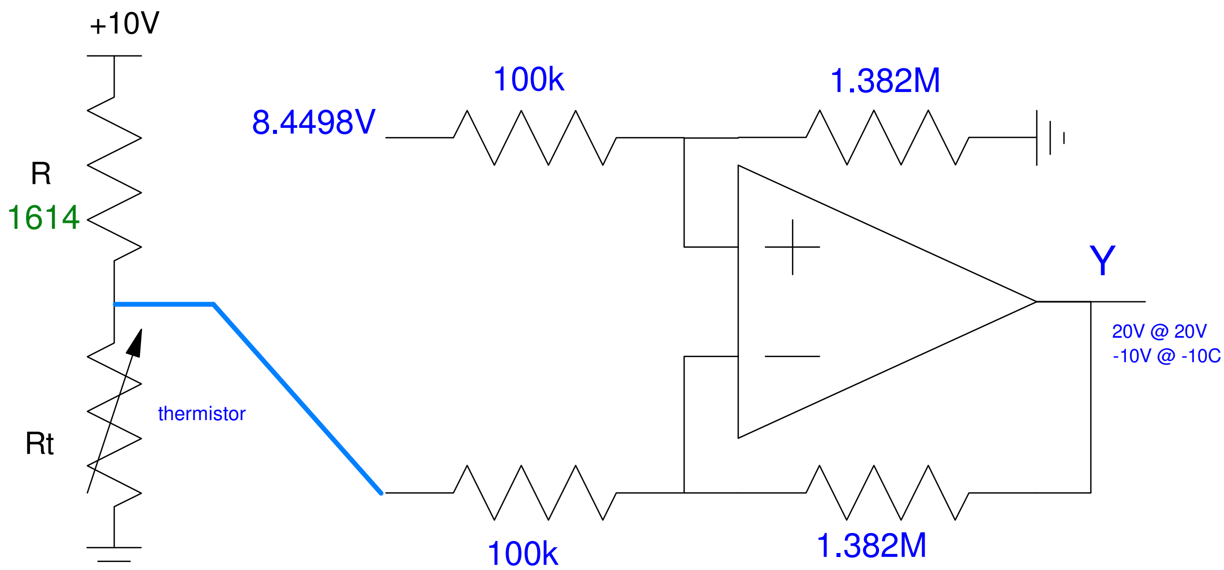
$$R_t = 3000 \cdot \exp\left(\frac{4000}{T+273} - \frac{4000}{298}\right)\Omega$$

Design a circuit which outputs

- +20V at +20C, and
- -10V at -10C

Assume

- R = 1100 + 100*(your birth month) + (your birth date)



20C

- Rt = 3772.2 Ohms
- X = 7.0035V

-10C

- Rt = 17,902 Ohms
- X = 9.173V

Y goes up as X goes down. Connect to the minus input

$$gain = \left(\frac{30V}{9.173V - 7.0035V}\right) = 13.82$$

Offset: At 20C, Y = 20V

$$Y = 20V = 13.82(A - 7.0035V)$$

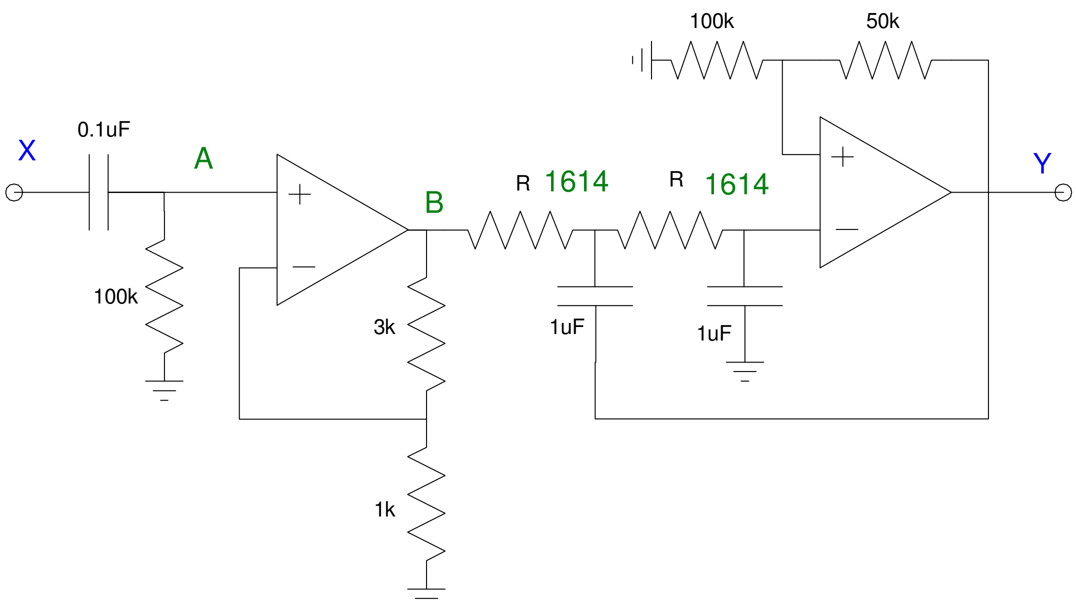
$$A = 8.4498$$

4. Filters: Let

- R 1100 + 100*(your birth month) + (your birth day). May 14th would give R = 1614 Ohms

Find the transfer function from X to Y

R 1100 + 100*mo + day	Transfer Function Y = G(s) * X
1614	$\left(\frac{s}{s+100}\right)(4)\left(\frac{1.5\cdot 619^2}{(s+619\angle 41.4^0)(s+619\angle -41.4^0)}\right)$



$$A = \left(\frac{R}{R+\frac{1}{Cs}}\right)X = \left(\frac{RCs}{RCs+1}\right)X = \left(\frac{s}{s+100}\right)X$$

$$B = 4A$$

complex poles

$$|pole| = \left(\frac{1}{RC}\right) = \left(\frac{1}{1614\cdot 1\mu F}\right) = 619$$

$$3 - k = 2\cos\theta$$

$$3 - 1.5 = 2\cos\theta$$

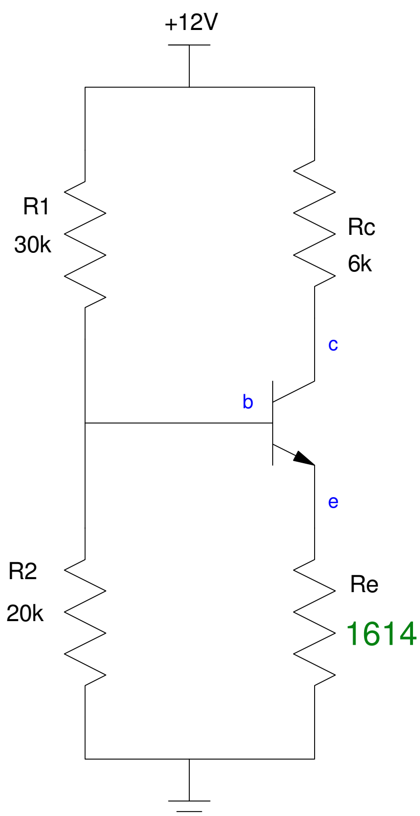
$$\theta = 41.4^0$$

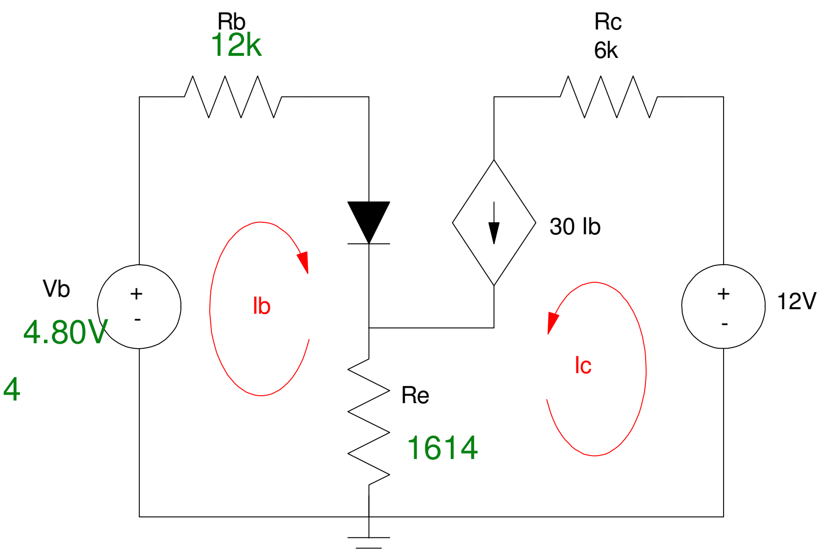
$$Y = \left(\frac{1.5\cdot 619^2}{(s+619\angle\pm 41.4^0)}\right)B$$

5. CE Amplifiers (DC analysis): Determine the Thevenin equivalent of R1 and R2 as well as the operating point for the following transistor circuit. Assume

- Re = 1100 + 100*(your birth month) + (your birth date)
- $\beta = 30$
- | Vce | = 0.7V

Re 1100 + 100*mo + day	Vb	Rb	Vce	Ic
1614	**4.80V**	**12k**	**0.2V** saturated	**1.55mA** saturated





$$I_b = \left(\frac{4.80V - 0.7V}{12k + 1614 \cdot 31}\right) = 66.09\mu A$$

$$I_c = 30 I_b = 1.983mA$$

$$V_c = 12 - 6k \cdot I_c = 0.1033V$$

$$V_e = 1614 \cdot (I_b + I_c) = 3.307V$$

$$V_{ce} = V_c - V_e = -3.204V$$

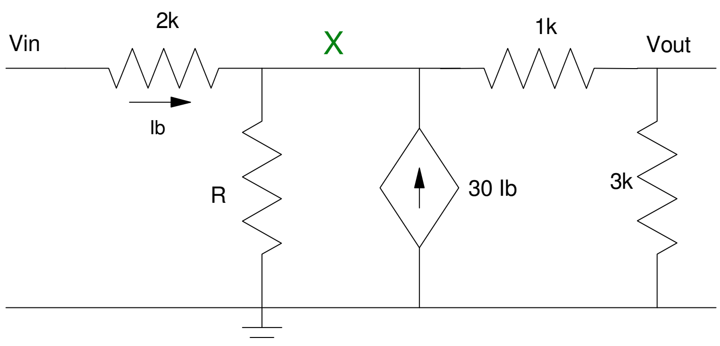
which tells you that the transistor is saturated

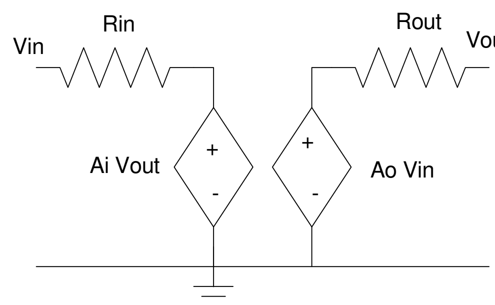
Vce = 0.2V

6. 2-Port model: Determine the 2-port parameters for the following circuit. Assume

- R = 1100 + 100*(your birth month) + (your birth date) Ohms

R 1100 + 100*mo + day	Rin	Ai	Rout	Ao
1614	**21.1k**	**0.6174**	**784**	**0.71**





Rin: Short Vout, apply 1V to Vin, compute the current

$$\left(\frac{X-1}{2k}\right)+\left(\frac{X}{1614}\right)+30\left(\frac{X-1}{2k}\right)+\left(\frac{X}{1k}\right)=0$$

$$X=0.9054V$$

$$I=\left(\frac{1V-0.9054V}{2k}\right)=47.3\mu A$$

$$R_{in}=\frac{1V}{47.3\mu A}=21.1k\Omega$$

Ao: Open Vout, apply 1V to Vin, compute Vout

$$\left(\frac{X-1}{2k}\right)+\left(\frac{X}{1614}\right)+30\left(\frac{X-1}{2k}\right)+\left(\frac{X}{4k}\right)=0$$

$$X=0.9524V$$

$$V_{out}=\left(\frac{3}{4}\right)X=0.7143$$

Rout: Shourt Vin, apply 1V to Vout, compute Iin

$$\left(\frac{X}{2k}\right)+\left(\frac{X}{1614}\right)+30\left(\frac{X}{2k}\right)+\left(\frac{X-1}{1k}\right)=0$$

$$X=0.05841V$$

$$I=\left(\frac{1V}{3k\Omega}\right)+\left(\frac{1V-0.05841V}{1k\Omega}\right)=1.275mA$$

$$R_{out}=\left(\frac{1V}{1.275mA}\right)=784\Omega$$

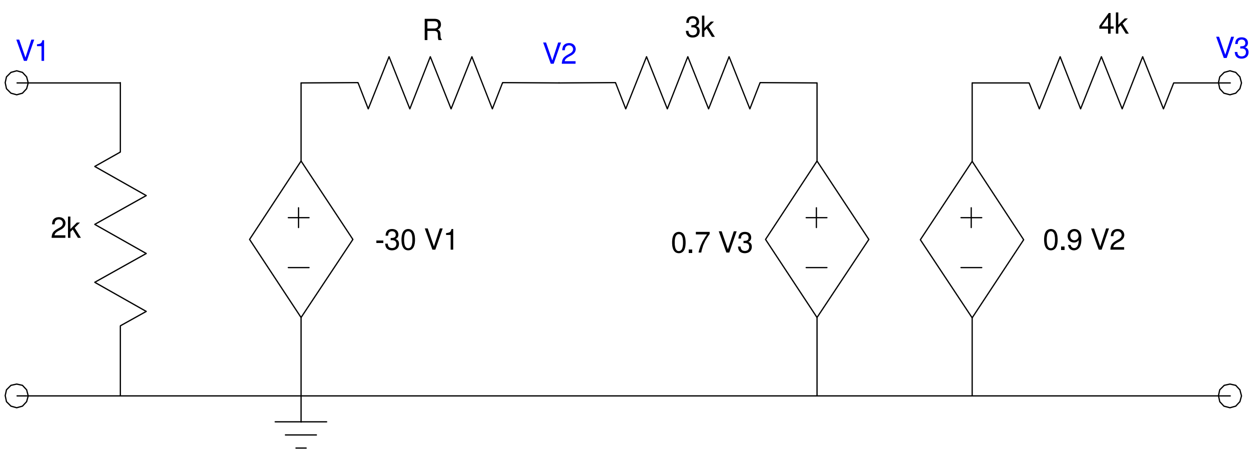
Ain: Open Vin, apply 1V to Vout, compute Vin

$$V_{in} = \left(\frac{1614}{1614+1k}\right) = 0.6174$$

7. 2-Port model: Determine the 2-port parameters for the following circuit. Assume

R = 1100 + 100*(your birth month) + (your birth date) Ohms

R 1100 + 100*mo + day	Rin	Ai	Rout	Ao
1614	**2k**	**0**	**5131**	**-22.52**



Rout: Short Vin, apply 1V to Vout

$$V_2 = \left(\frac{1614}{1614+3000}\right)0.7V = 0.2449V$$

$$I = \left(\frac{1V - 0.9\cdot 0.2449V}{4k}\right) = 194.9\mu A$$

$$R_{out} = \left(\frac{1V}{194\mu A}\right) = 5131\Omega$$

Ao: Apply 1V to Vin. Compute Vout

$$V_2 = \left(\frac{3k}{1614+3k}\right)(-30V) + \left(\frac{1614}{1614+3000}\right)(0.7)(0.9V_2)$$

$$V_2 = -25.02V$$

$$V_3 = 0.9V_2 = -22.52$$