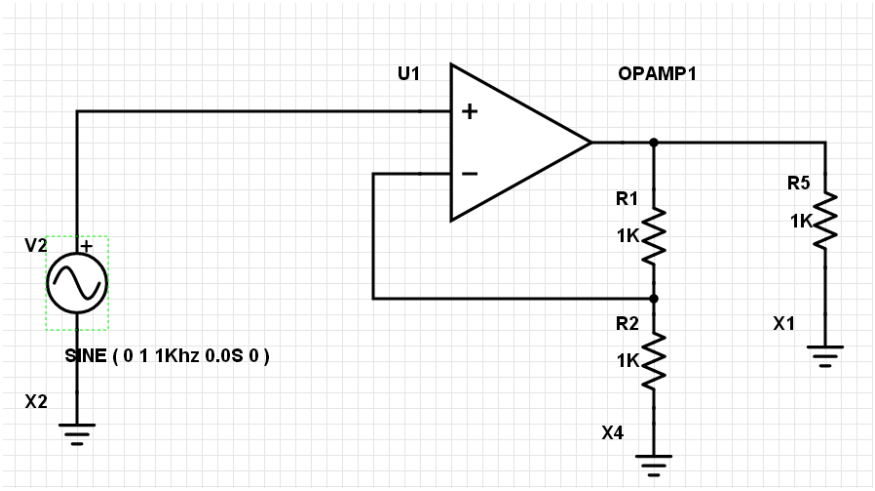
EE 206: Solution #7

Op Amp Amplifiers. Due Wed, Feb 20th

1) Design an op-amp circuit to implement

Y = 2X

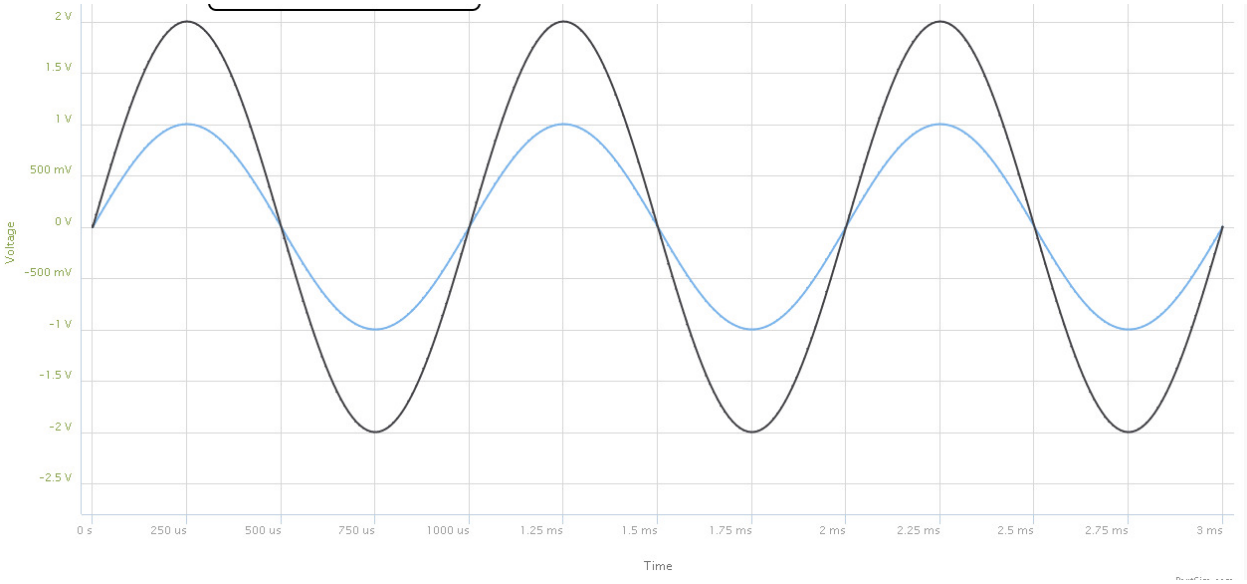
$$gain = 2 = 1 + \frac{R_1}{R_2}$$



Simulate this circuit in PartSim with

- x(t) = 1Vp, 1kHz sine wave

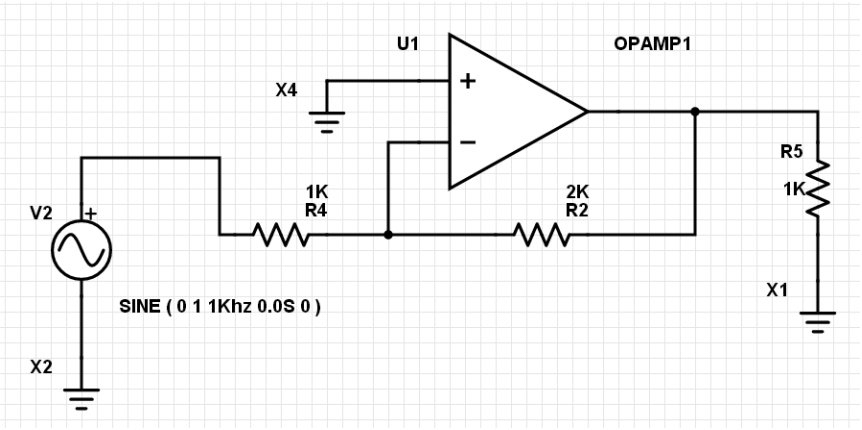
Is Y double X? Yes



2) Design an op-amp circuit to implement

Y = -2X

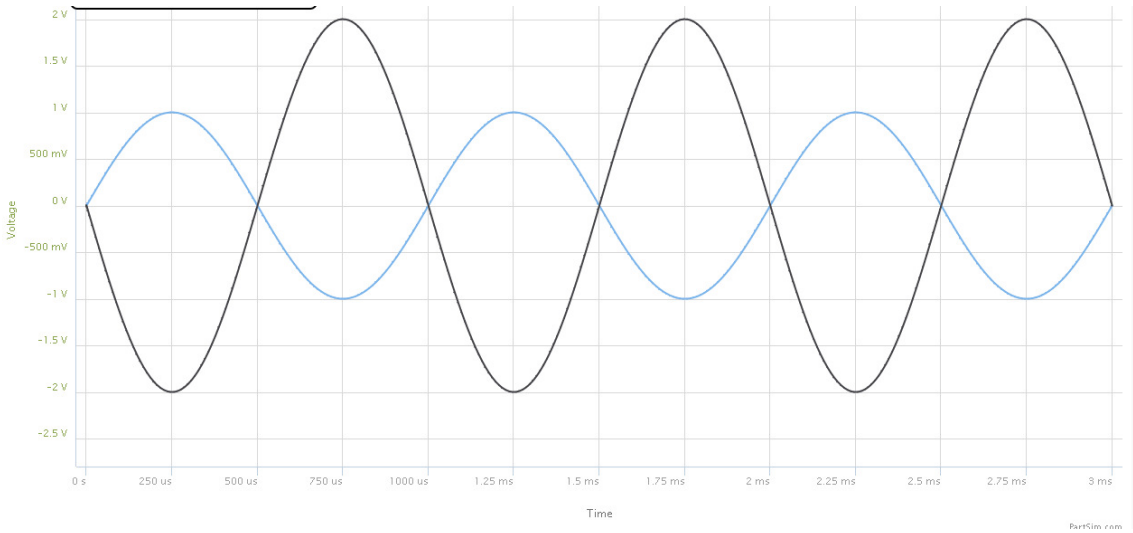
$$gain = -2 = -\frac{R_2}{R_1}$$



Simulate this circuit in PartSim with

- x(t) = 1Vp, 1kHz sine wave

Is Y double X and 180 degrees out of phase?



3) Design an op-amp circuit to implement

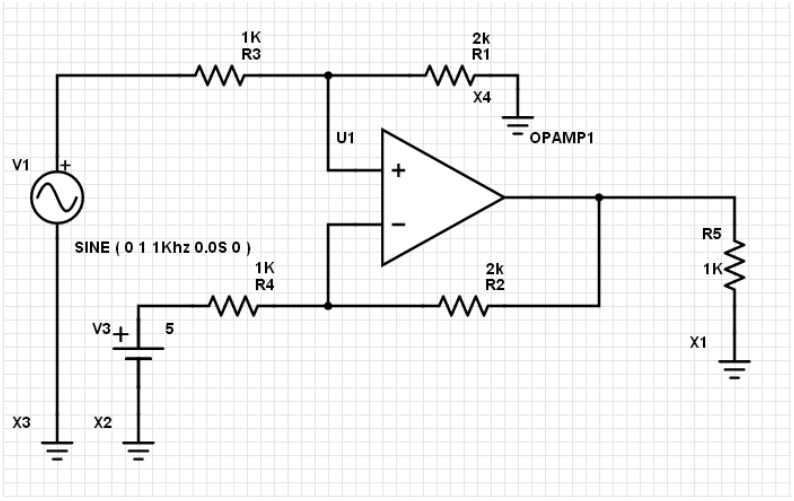
Y = 2X - 10

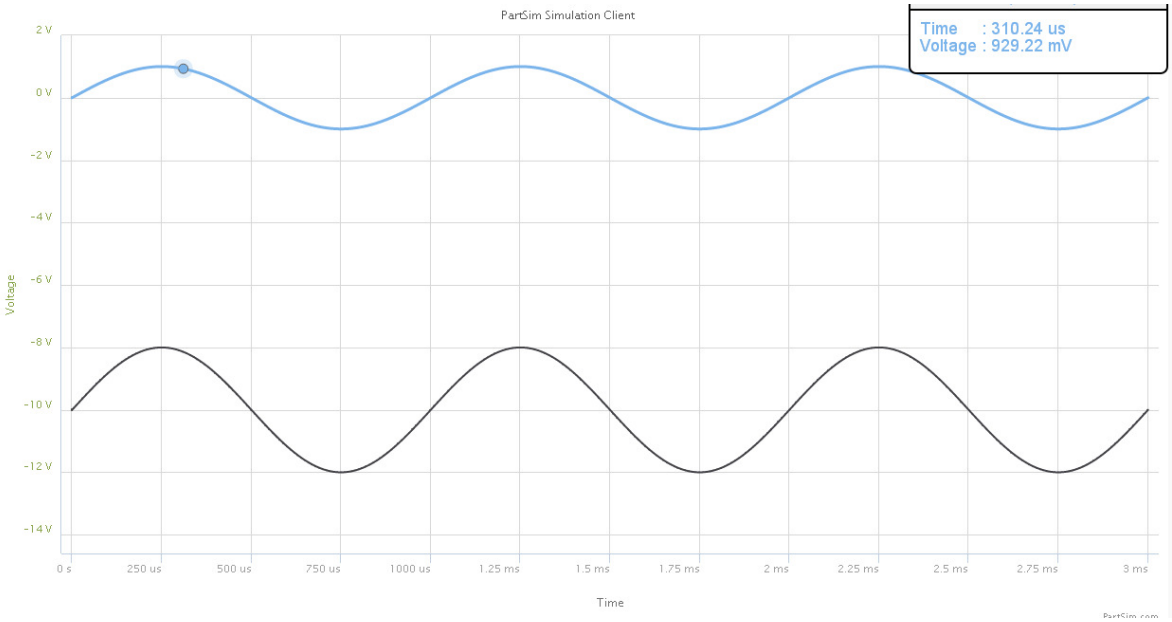
Rewrite as

$$Y = 2(X - 5)$$

Use an instrumentation amplifier

$$Y = \left(\frac{R_2}{R_1}\right)(V_p - V_m)$$





- Input (blue) = 2Vpp, Output = 4Vpp (gain = 2)
- Output is in phase with the input (gain is + 2)
- Output has a DC offset of -10V

4) Design an op-amp circuit which outputs

- -10V when R = 1000 Ohms
- +10V when R = 2000 Ohms

Assume a voltage divider with a 1500 Ohm resistor

R = 1000 (Vo = -10V)

$$V_a = \left(\frac{1000}{1000+1500}\right) 10V = 4V$$

R = 2000 (Vo = +10V)

$$V_a = \left(\frac{2000}{2000+1500}\right) 10V = 5.7143V$$

The gain you need for a 20V spread at the output is

$$gain = \left(\frac{10V-(-10V)}{5.7143V-4V}\right) = 11.6667$$

Plugging in the right endpoint

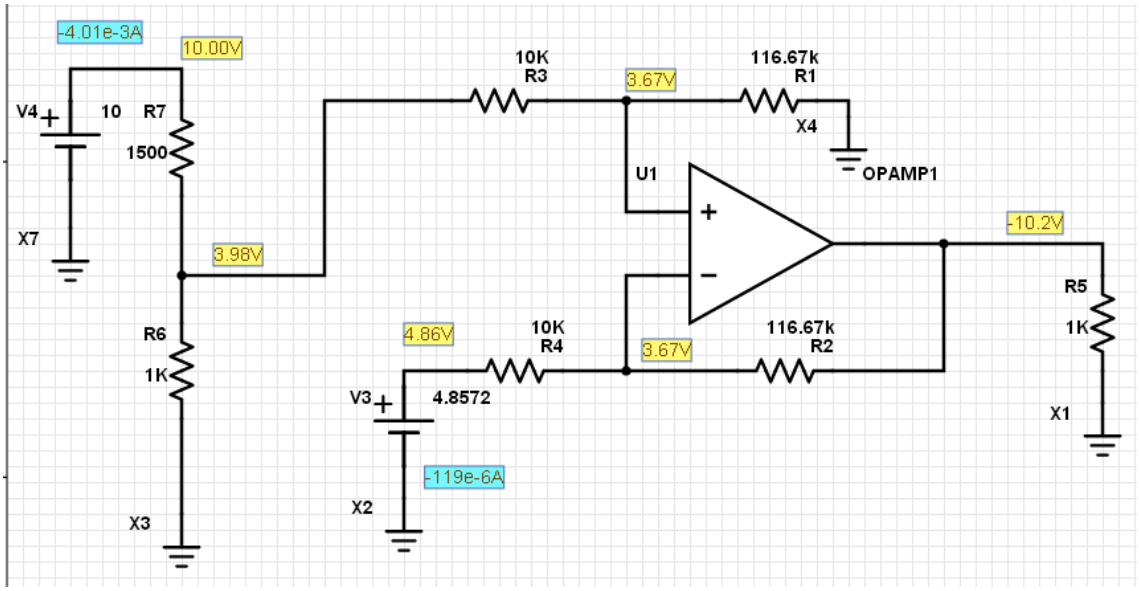
$$V_{out} = gain(V_p - V_m)$$

$$10 = 11.6666(5.7143V - V_m)$$

$$V_m = 4.8572V$$

or... the output should be 0V at the midpoint

$$V_m = \left(\frac{4V+5.7143V}{2}\right) = 4.8572V$$



5) Simulate the circuit for problem #4. Plot the output voltage for 1000 < R < 2000 Ohms

	Vout		
R	Calculated prob 4 - ignoring loading	Calculated including loading	Simulated prob 5
1000	-10	-10.2206	-10.2
1200	-4.81	-5.0869	-5.09
1400	-0.34	-0.6656	-0.67
1600	3.54	3.1819	3.18
1800	6.96	6.5606	6.56
2000	10	9.512	9.55

Sample Calculations: (ignoring loading of the 10k and 116k)

$$V_p = \left(\frac{R}{R+1500}\right) 10V$$

$$V_{out} = 11.6667 \cdot (V_p - 4.8572)$$

Sample Calculations (including the loading of the 10k and 116k resistors)

$$V_p = \left(\frac{R||126.67k}{R||126.67k+1500}\right) 10V$$

Note that our design is a little off due to the effect of loading. To reduce this effect, make the resistors for the instrumentation amplifier much larger than the voltage divider.