EE 206: Homework #7 Solution

Op Amp Amplifiers. Due Monday, March 9th

1) Design an op-amp circuit to implement

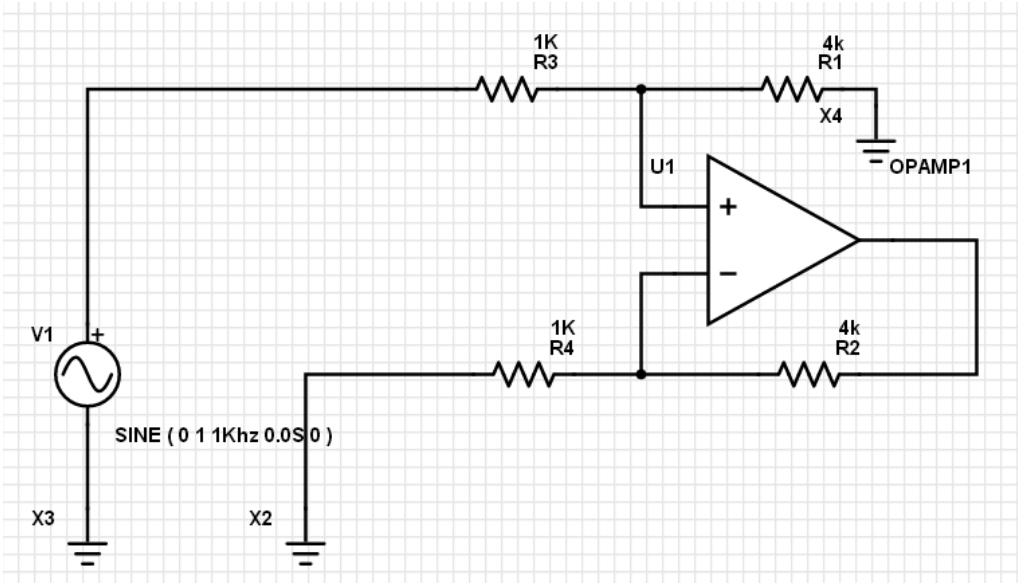
$$Y = 4X$$

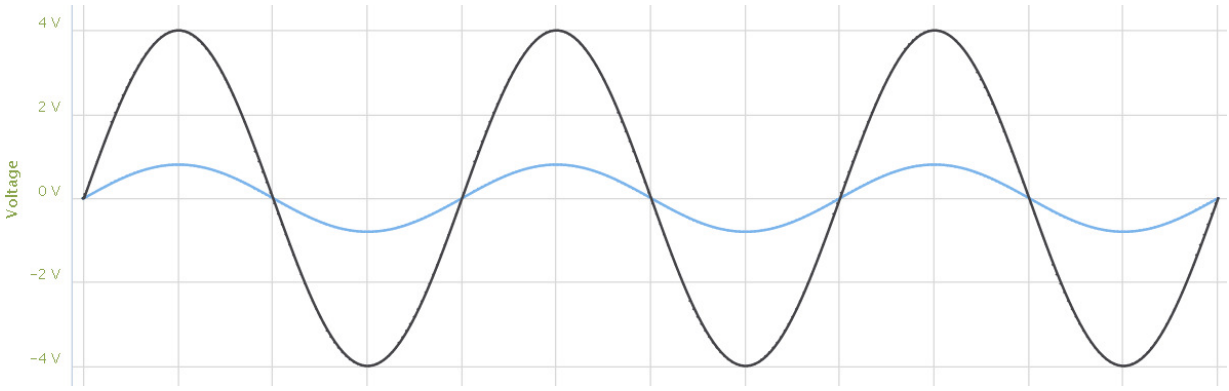
Simulate this circuit in PartSim with

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

Is Y double X and 180 degrees out of phase?

There are multiple solutions. This is one:





Yes, the output (black) is 4x the input (blue) and in phase with it.

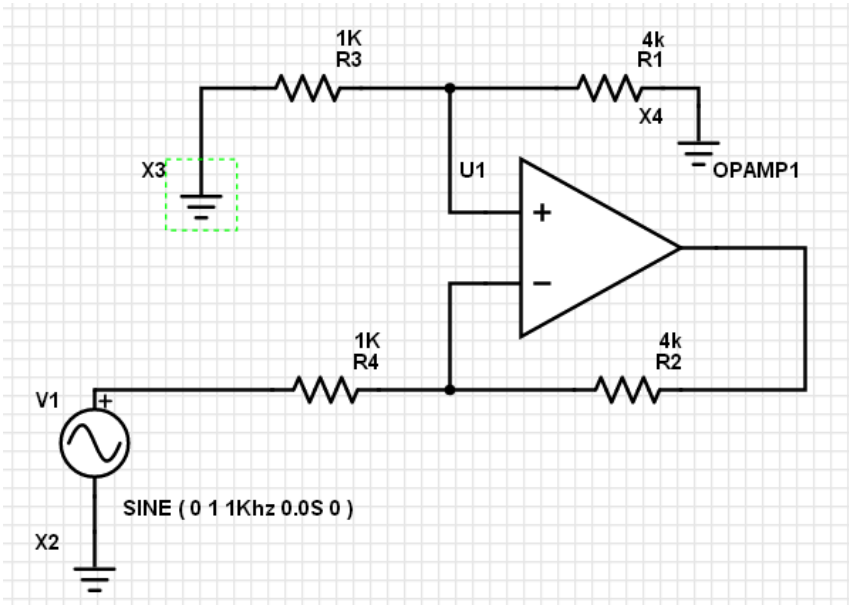
2) Design an op-amp circuit to implement

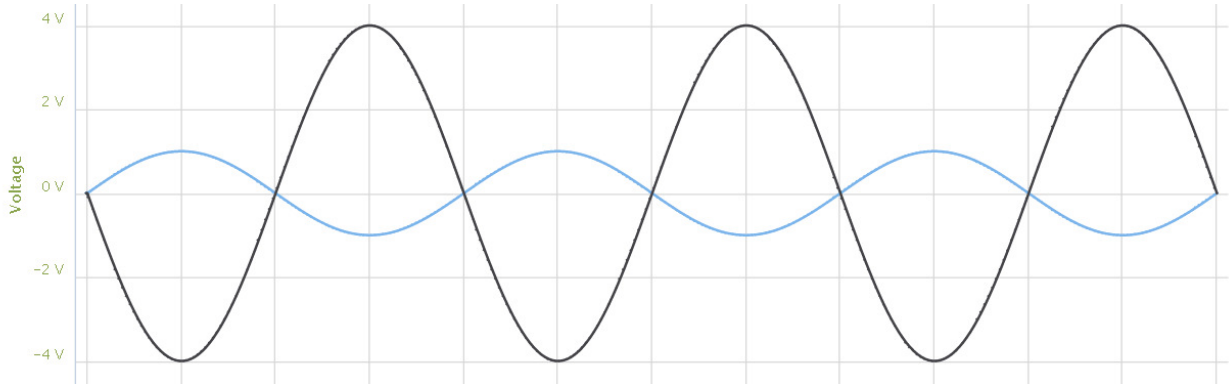
$$Y = -4X$$

Simulate this circuit in PartSim with

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

Is Y double X and 180 degrees out of phase?





Vin (blue) and Vout (black)

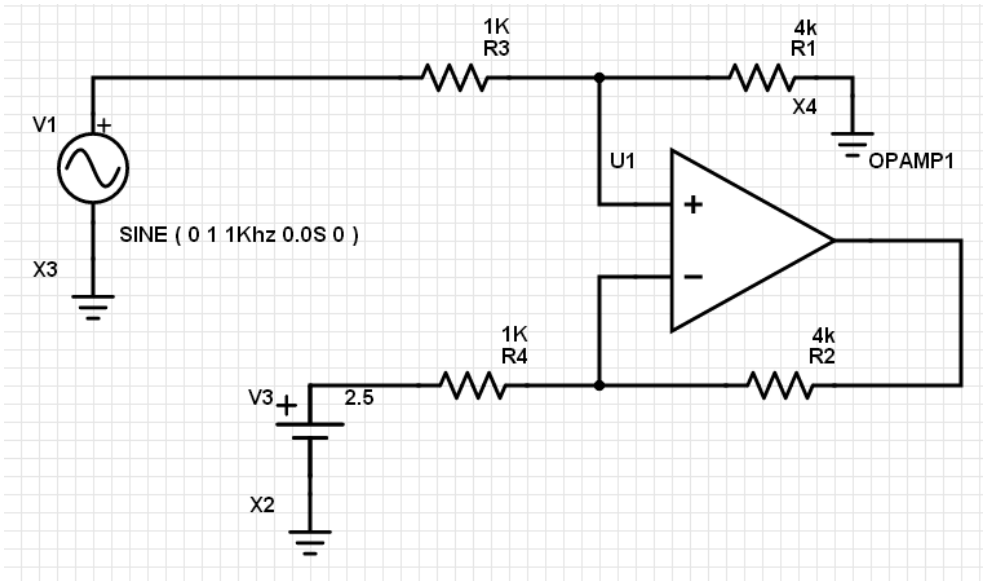
Yes, the output is 4x the input, 180 degrees out of phase from the input

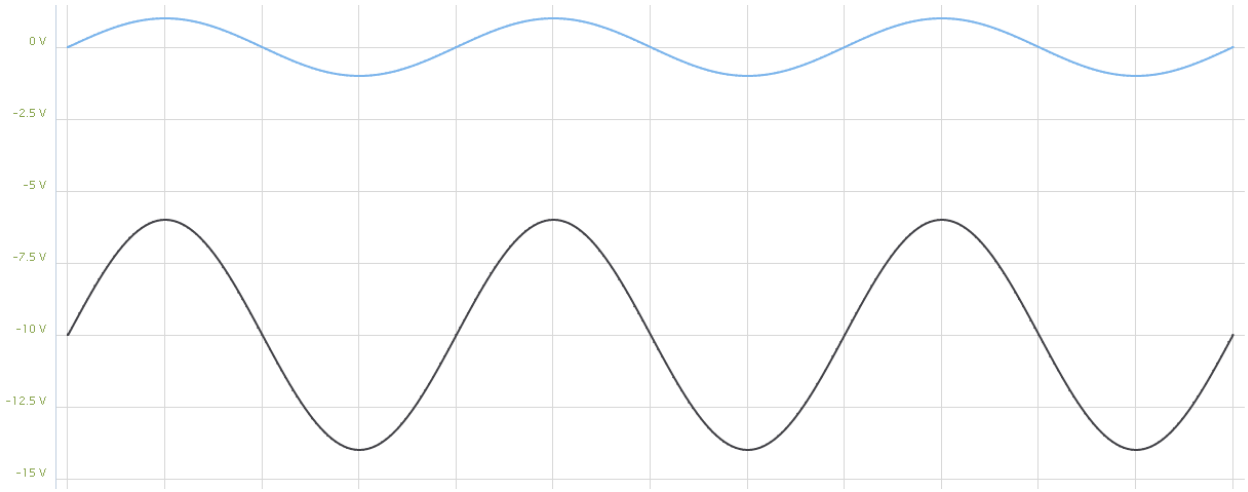
3) Design an op-amp circuit to implement

$$Y = 4X - 10$$

Rewrite as

$$Y = 4(X - 2.5)$$





Vin (blue) and Vout (black)

Note that

- Vout is 4x larger than Vin (gain is 4x)
- In phase with Vin (gain is +)
- Shifted down by 10V

4) Design an op-amp circuit which outputs

- -10V when R = 1000 Ohms
- +10V when R = 1200 Ohms

Assume a voltage divider with 1000 Ohms

R = 1000: (Vo = -10V)

$$V_x = \left(\frac{1000}{1000+1000}\right) 10V = 5V$$

R = 1200: (Vo = +10V)

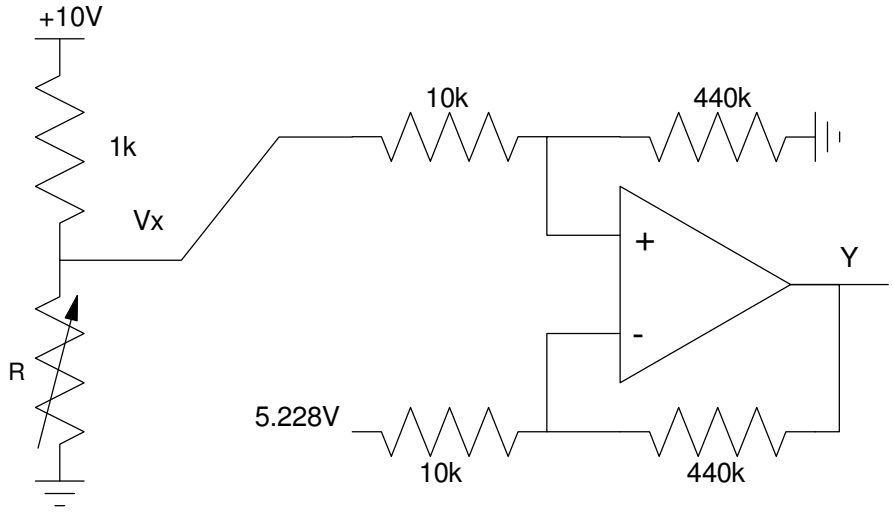
$$V_x = \left(\frac{1200}{1200+1000}\right) 10V = 5.455V$$

The gain we need is

$$gain = \left(\frac{\text{change in output}}{\text{change in input}}\right) = \left(\frac{20V}{0.455V}\right) = 44.00$$

The output is 0V at the midpoint

$$offset = \left(\frac{5V+5.455V}{2}\right) = 5.228V$$



5) Simulate the circuit for problem #4. Plot the output voltage for 1000 < R < 1200 Ohms

	Vout		
R	Calculated prob 4 - ignoring loading	Calculated including loading	Simulated prob 5
1000	-10.00	-10.244	-10.244
1050	-4.634	-4.890	-4.890
1100	0.476	0.208	0.208
1150	5.349	5.070	5.070
1200	10.000	9.710	9.710

Calculations: Ignoring Loading

$$V_x = \left(\frac{R}{R+1000}\right) 10V$$

$$V_y = 44(V_x - 5.22727V)$$

Calculations: Including Loading

$$R_p = R||450k$$

$$V_x = \left(\frac{R_p}{R_p+1000}\right) 10V$$

$$V_y = 44(V_x - 5.22727V)$$