This exam is for 2 hours, and carries maximum of 20 points.

Save all measurement data in .ods or .xls file with filename as <rollnumber_name>

Use ± 13V as supply voltages for op-amps.

1. (4 points) Analyze the circuit shown below **without building it on your breadboard**. If we connect a 300Hz sine wave with (amplitude greater than V_{CC}) at the input, what output will you expect? (Sketch the waveform on this page in the space provided below, with well labeled axes indicating voltage levels clearly). *This part should require approximately 15 minutes.*
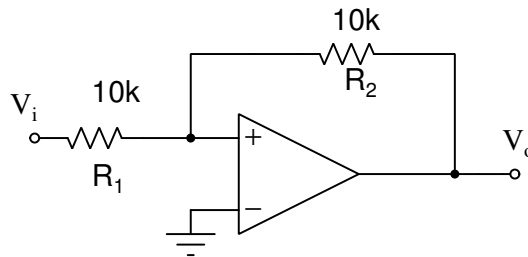
2. Build the circuit shown below on your breadboard using TL084. Confirm the component values before connecting them (read the colour code on resistors and marking on the capacitors). Measure its frequency response (amplitude only) from 3kHz to 7kHz. *This part should require approximately 60 minutes.*
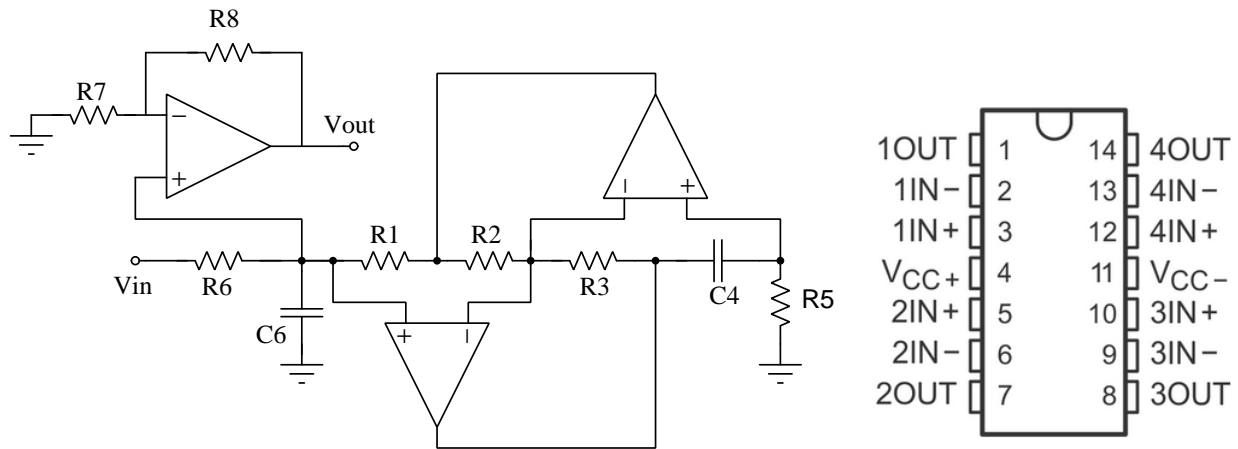

Figure 1: Use R1=R2=R3=R5=6.8kΩ, R6=820kΩ, C4=C6=4.7nF, R7=R8=10kΩ

(a) (5 points) What amplitude response do you observe in the Bode plot? Provide the Bode plot with raw data (measurement table) to your TA on pen drive.

Ans. **Explain in words**, what you observe.

(b) (5 points) Suggest any suitable application of such a circuit. What performance parameters of this circuit will be useful in such application?

Ans.

3. (a) (3 points) How will you use above circuit of Q2 to accept input sine wave at frequency f_0, and provide a sine wave at its output with frequency $5f_0$. Do not change any circuit components, but you may connect additional input or output stages if needed. The output frequency could be any value of your choice between 3kHz and 7kHz. Draw circuit diagram below and justify your answer (represent the circuit of Q2 as a black-box with one input and one output, instead of re-drawing it).

Ans.

(b) (3 points) Build your proposed circuit on bread-board and show functional waveforms on oscilloscope to your TA. You will not get any additional components beside the ones provided to you.

For TA use only, Q3(b): Please circle one of the options below and sign.

- Demo **IS** successful. :)

- Demo **IS NOT** successful. :(