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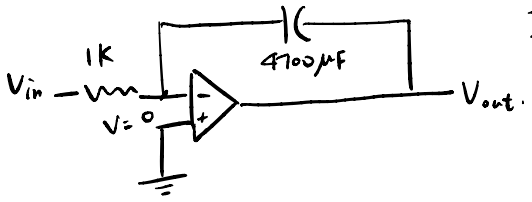
Experiment 5 Pre-Lab
ECE203 Spring 2025
Due at the beginning of your lab session.
Turn in a paper copy to your TA. You must submit your own copy.

In the lab, we will build two new op-amp circuits: An integrator and a differentiator.

1. (3 points) For the integrator in Section 5.3, suppose
   $v_{in}(t) = 1Vcos(2\pi 4kt) + 2\mu V$
   Find $v_{out}(t)$



$I = \frac{V_{in}}{R}$ $\quad V_c = -\int \frac{I}{C}dt = -\int \frac{V_{in}}{RC}dt$

$V_{out} = -V_c = \int \frac{V_{in}}{RC}dt = \int \frac{\cos(2\pi \cdot 4kt) + 2\mu}{1k \cdot 4700\mu}dt = \frac{1}{4.7}\left[\frac{\sin(8000\pi t)}{8000\pi} + 2\mu t\right]$

$= \boxed{8.4\times10^{-6}\sin(8000\pi t) + 4.26\times10^{-7}t}$

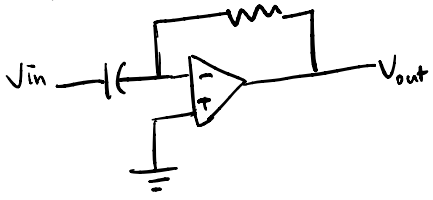
2. (3 points) Suppose the initial voltage $v_{out}(t)= 0V$. Find the voltage v_{out} after 3 seconds. Assume the op-amp is powered with ±15V. Does the op-amp power supply limit the output?

$V_{out}(3s) = 8.4\times10^{-6}\sin(24000\pi) + 4.26\times10^{-7}\times 3$

$= \boxed{1.27\ \mu V}$ $\quad$ within $\pm 15V$ $\Rightarrow$ Does not limit output

3. (1 point each) When working in the lab, one of the most common complaints is "There's nothing on my scope." Sometimes you're right, but oftentimes, your zoom is just wrong. For the differentiator in the background of the lab manual, suppose v_{in} = 10mV at 5kHz, R is 2kΩ, and C is 0.1μF. Determine a reasonable vertical scaling in V/div for v_{out}, and a reasonable horizontal scaling in μs/div.

Differentiator



$V_{out} = -\frac{d}{dt}(RC\,V_{in})$

$V_{in} = 10mV\cos(2\pi ft)$

$V_{out} = -\frac{d}{dt}\left[RC\,(10mV)\cos(2\pi ft)\right]$

$= (2\pi RCf)\cdot(10mV)\cdot\sin(2\pi ft)$

$V_{out,amp} = (2\pi RCf)\cdot(10mV) = 2\pi \times 2k\cdot 0.1\mu\cdot 5k\cdot 10m$

$= 2\pi\cdot 10\cdot m = 0.02\pi V = 0.063V = 63mV$

$\Rightarrow \frac{63mV}{4} = 15.75\ \frac{mV}{div}$ $\quad \frac{63mV}{5} = 12.6mV/div \Rightarrow$ $\boxed{\frac{20mV}{div}}$ closest vertical

$T = \frac{1}{f} = \frac{1}{5000} = 200\mu s \Rightarrow \frac{200\mu s}{10} = \boxed{\frac{20\mu s}{div}}$ horizontal