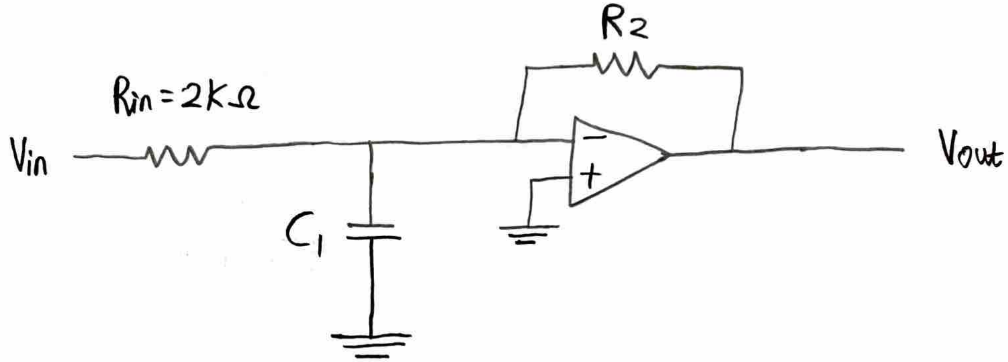
Noble Huang (Mulia Widjaja)

Prelab 3

4/22/2023

Equipment: 741 op-amp



purposes:

Active Low pass filter circuit with

① Gain at DC ($\omega = 0$):

$\frac{V_{out}}{V_{in}} = -15$ V/V → inverting amplifier

② $R_{in} = 2\ K\Omega$

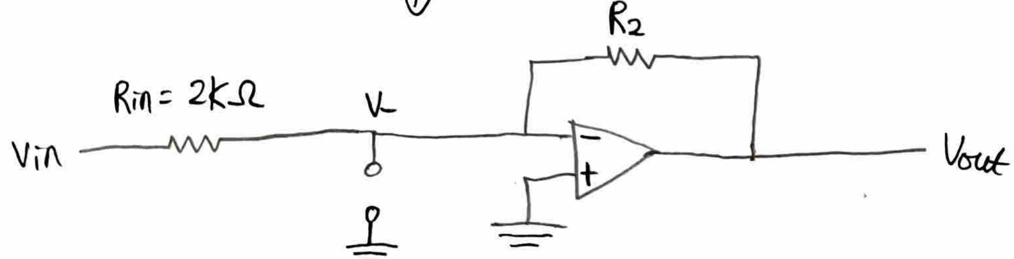
③ When 3 dB:

$f = 5000$ HZ

Z_c at DC ($\omega = 0$):

$Z_c = \frac{1}{j\omega C_1} = \frac{1}{j(0)C_1} = \infty$ → open circuit

↓



KCL (to find R_2):

$$\frac{V_- - V_{in}}{R_{in}} + \frac{V_- - V_{out}}{R_2} = 0$$

$$R_2(V_- - V_{in}) + R_{in}(V_- - V_{out}) = 0$$

$V_+ = 0 \xrightarrow{V_- = V_+} V_+ = V_- = 0$

$$-R_2 V_{in} - R_{in} V_{out} = 0$$

Assume ideal op-amp → $A = \infty$

↓

$V_o = A(V_+ - V_-)$ → $\frac{V_o}{A} = V_+ - V_-$

↓ $\frac{V_o}{\infty} = 0$

$0 = V_+ - V_-$ → $V_- = V_+$

KCL (Continued):

$$-R_2 V_{in} - R_{in} V_{out} = 0$$

$$R_2 V_{in} + R_{in} V_{out} = 0$$

$$R_{in} V_{out} = -R_2 V_{in}$$

$$\frac{V_{out}}{V_{in}} = -\frac{R_2}{R_{in}}$$

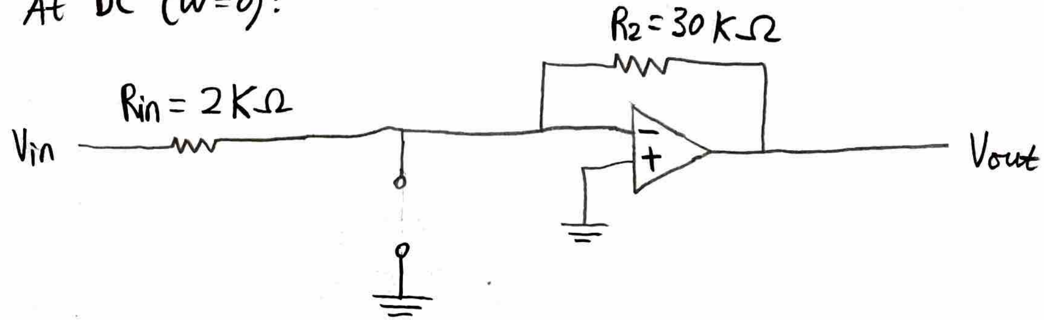
$$\boxed{\frac{V_{out}}{V_{in}} = -15}$$

$$\boxed{R_{in} = 2000\ \Omega}$$

$$-15 = -\frac{R_2}{2000}$$

$$R_2 = 30\ K\Omega$$

At DC ($w=0$):



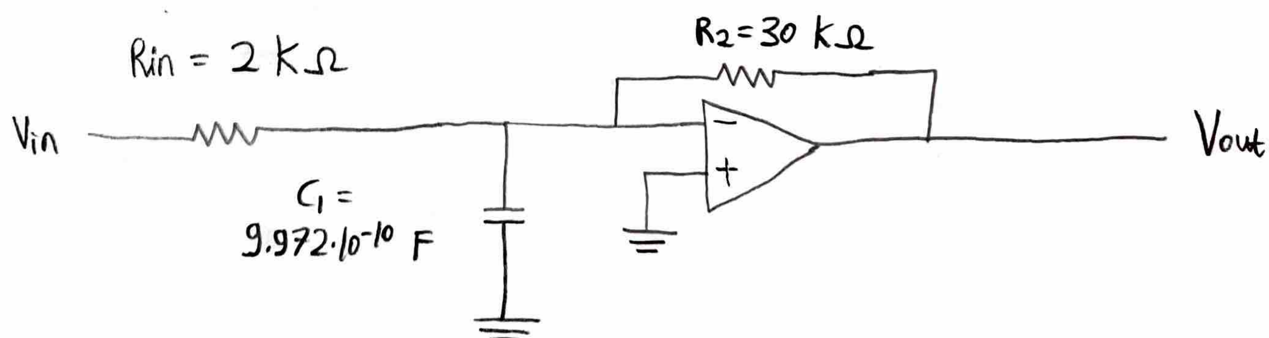
To find C_1:

$$f_0 = \frac{1}{2\pi (R_{in} + R_2) C_1}$$

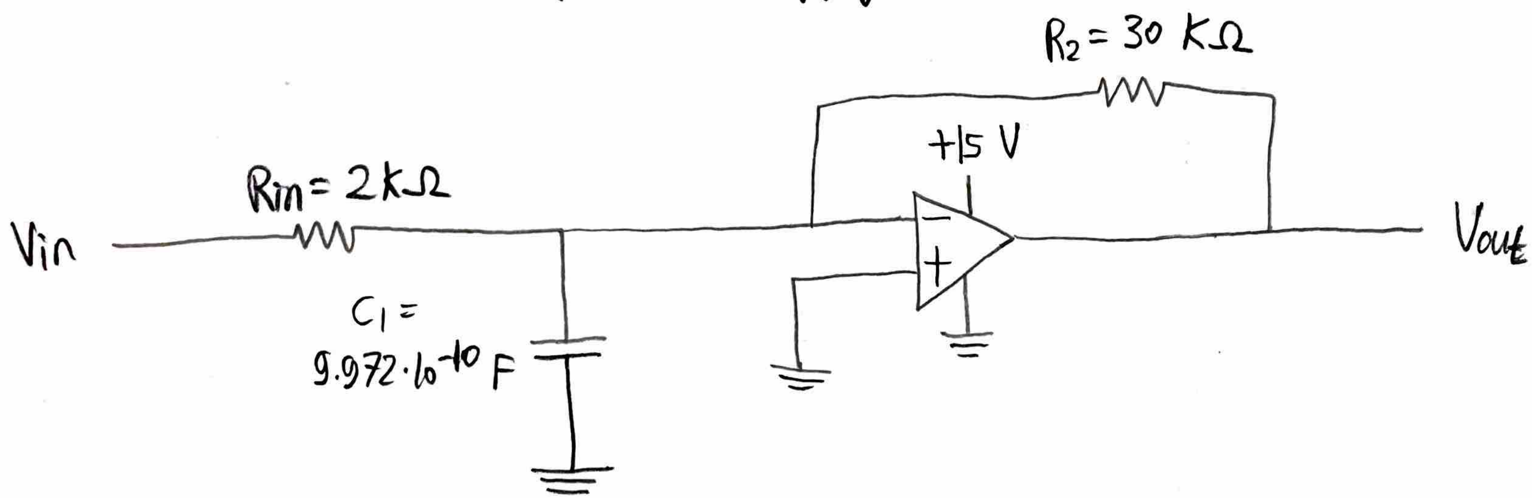
$$5000 = \frac{1}{2\pi (32000) C_1}$$

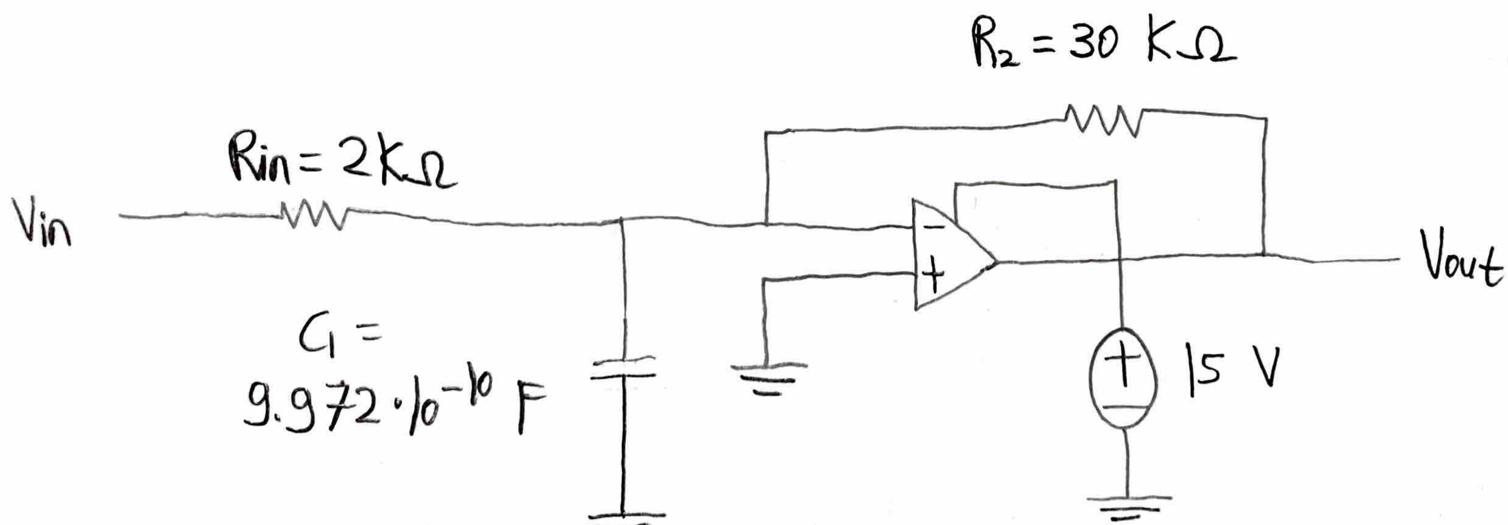
$$C_1 = 9.972 \cdot 10^{-10}\ F$$

My final filter design (Generalized for every value of w):



(6.) Assign ± 15 V DC power supply:



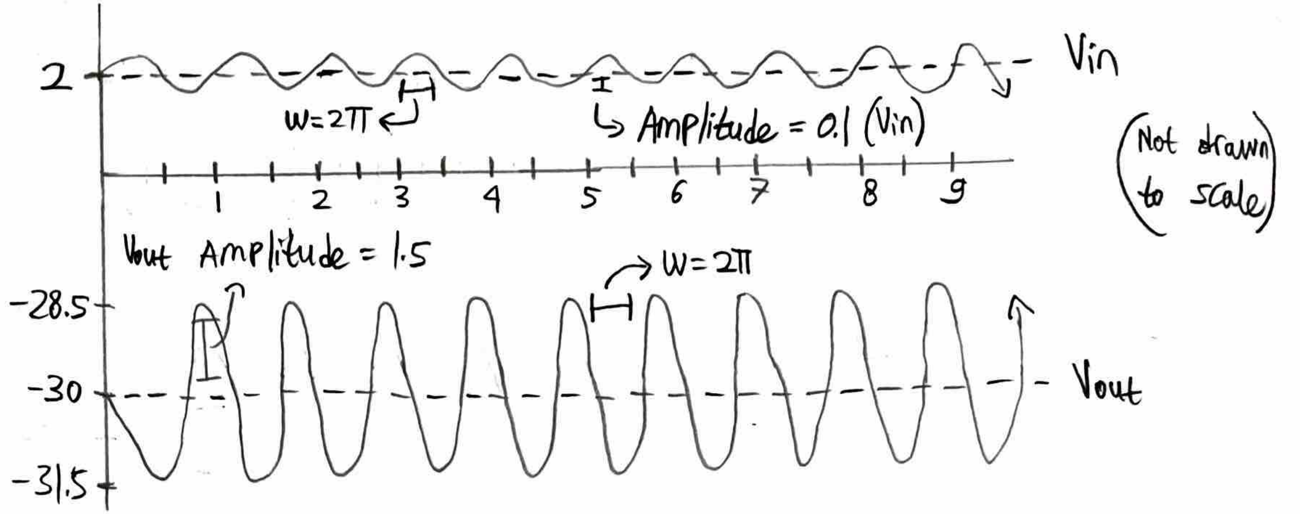


(c) (i) $V_{in}(t) = 2 + 0.1 \sin 2\pi t$

$$V_{out}(t) = V_{in}(t) \cdot \frac{V_{out}}{V_{in}}$$

$$= \left[2 + 0.1 \sin(2\pi t)\right] \cdot (-15)$$

$$= -30 - 1.5 \sin(2\pi t)$$

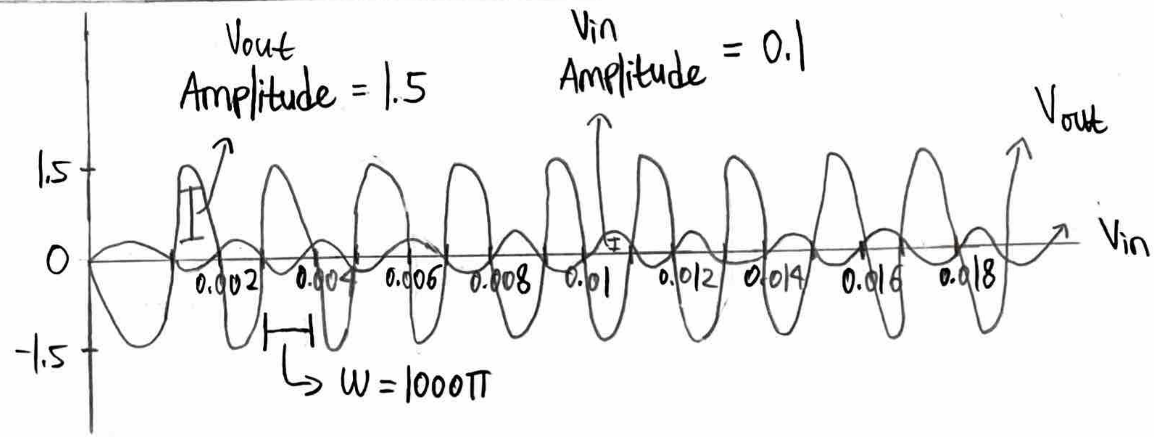


(ii) $V_{in}(t) = 0.1 \sin(1000\pi t)$

$$V_{out}(t) = V_{in}(t) \cdot \frac{V_{out}}{V_{in}}$$

$$= \left[0.1 \sin(1000\pi t)\right](-15)$$

$$= -1.5 \sin(1000\pi t)$$



(iii) $V_{in}(t) = 0.1 \sin(40000\pi t)$

$$V_{out}(t) = V_{in}(t) \cdot \frac{V_{out}}{V_{in}}$$

$$= \left[0.1 \sin(40000\pi t)\right](-15)$$

$$= -1.5 \sin(40000\pi t)$$