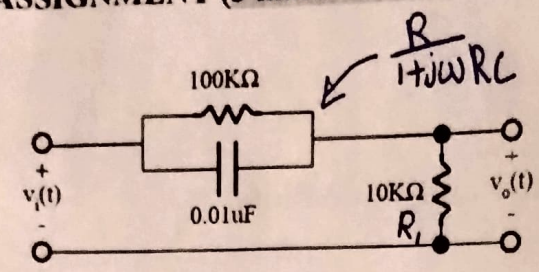
4.0 PRE-LAB ASSIGNMENT (3 marks with 1.5 marks for each step):



$$\left(\frac{\frac{R}{1+j\omega RC}}{R_1}\right)\cdot\frac{R_1}{R} = \left(\frac{R}{R_1}+j\omega RC\right)\cdot\frac{R_1}{R}$$

$$= (1+j\omega RC)$$

Figure 1.0: An One Pole-One Zero Circuit

(a) Step 1: Consider the network shown in **Figure 1.0**.

i) Derive the transfer function $H(s) = {}^{V_o}/_{V_i}$, where V_o is the phasor representation of $v_o(t)$ and V_i is the phasor representation of $v_i(t)$.

Pre-Lab workspace (show your analysis here)

$$H(\omega) = \frac{V_o}{V_i} \Rightarrow V_o = \frac{R_1}{R_1+\frac{R}{1+j\omega RC}}V_i = \frac{R_1(1+j\omega RC)}{(R_1+\frac{R}{1+j\omega RC})(1+j\omega RC)}$$

zero

$$\frac{R_1(1+j\omega RC)}{R_1(1+j\omega RC)+R} \Rightarrow \frac{1+j\omega RC}{1+j\omega RC+\frac{R}{R_1}}$$

since $\frac{R}{R_1} = 100$

$$\Rightarrow \frac{1+j\omega RC}{\frac{R}{R_1}+j\omega RC} \times \frac{R_1}{R} = \left(\frac{R_1}{R}\right)\left(\frac{1+j\omega RC}{1+j\omega RC}\right)$$

$\frac{R}{R_1} \gg 1$

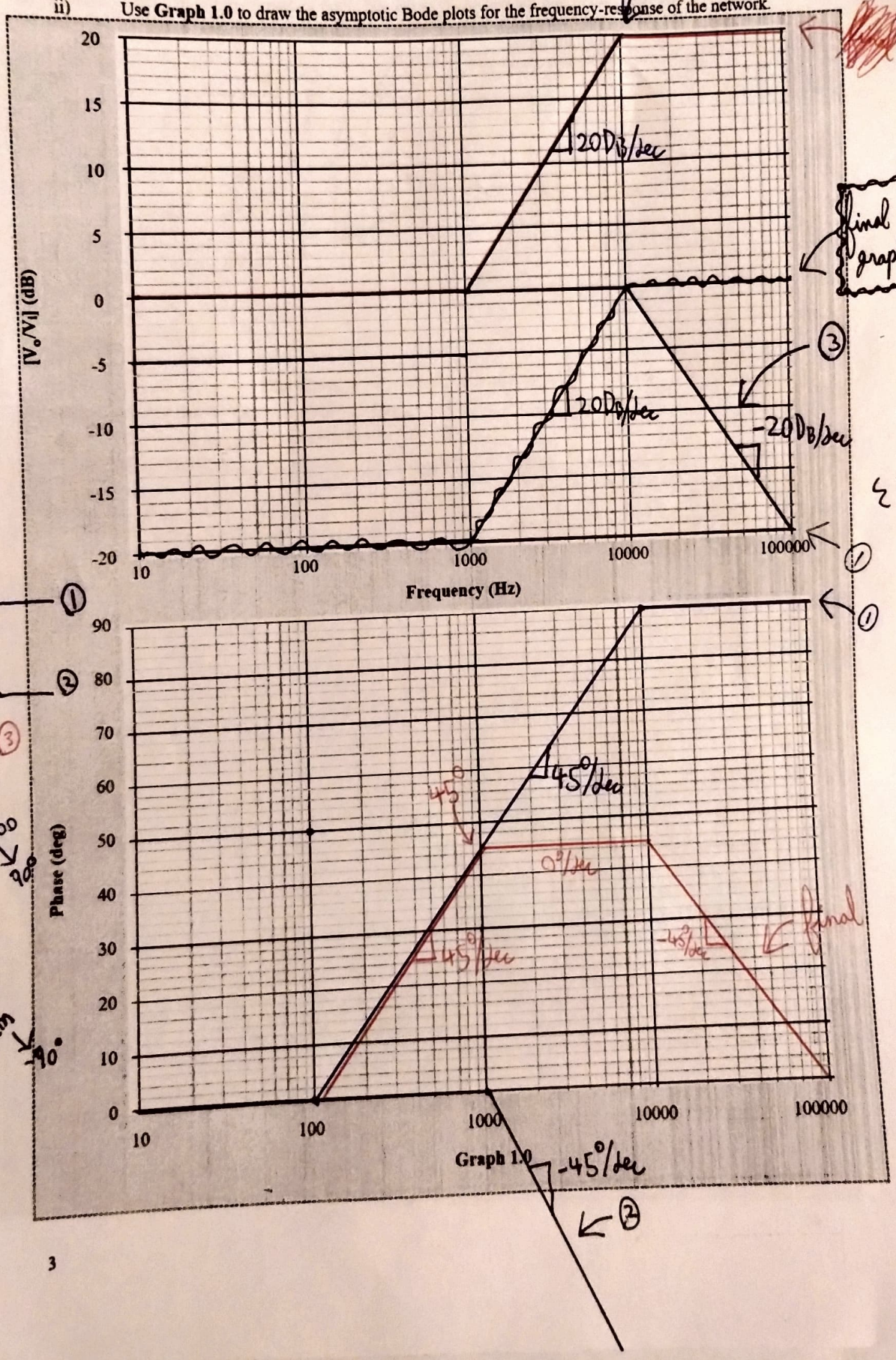
constant — pole

$$\frac{V_o}{V_i} = \frac{10K}{100K}\cdot\frac{1+j\frac{\omega}{1000}}{1+j\frac{\omega}{10000}}$$

($\frac{1}{RC}$ = 1000, $\frac{1}{R_1C}$ = 10000)

$$\frac{V_o}{V_i} = 0.1\,\frac{1+j\frac{\omega}{1000}}{1+j\frac{\omega}{10000}}$$

ii) Use **Graph 1.0** to draw the asymptotic Bode plots for the frequency-response of the network.



iii) Use Multisim to plot the magnitude in dB and phase in degrees of the frequency-responses of the above circuits, for $10Hz \leq f \leq 100kHz$. (Note: Simulate->Instruments->Bode Plotter can be used in creating the plots).

Pre-Lab workspace (show your analysis here)

$V_A = V_B$

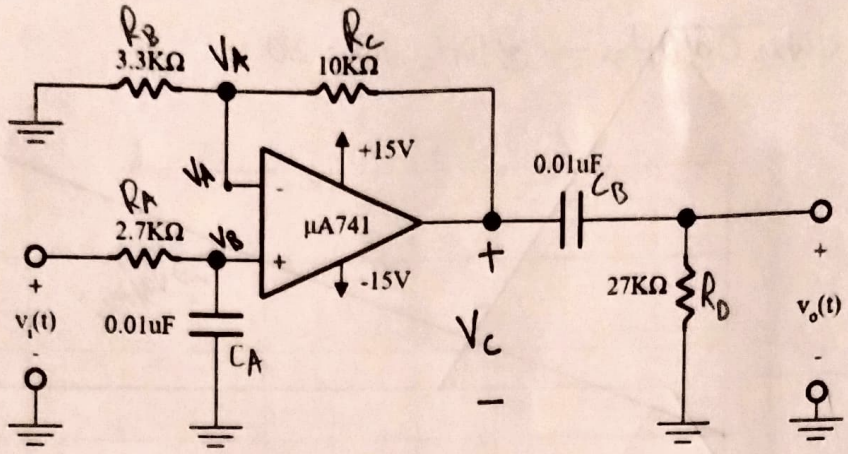


Figure 2.0: A Two Poles-One Zero Circuit

(b) Step 2: Assume that the Op-Amp circuit in **Figure 2.0** is working properly.

i) Derive the transfer function $H(s) = {}^{V_o}/_{V_i}$.

Pre-Lab workspace (show your analysis here)

$$V_B = \frac{\frac{1}{j\omega C_A}}{R_A + \frac{1}{j\omega C_A}} V_i \Rightarrow \frac{V_B}{V_i} = \frac{1}{1 + j\omega R_A C_A}$$

$V_A = V_B$ KCL @ node V_A: $\frac{V_B - 0}{R_B} + \frac{V_B - V_C}{R_C} = 0 \Rightarrow \frac{V_B}{R_B} = \frac{-V_B + V_C}{R_C}$

$$V_o = \frac{R_D}{R_D + \frac{1}{j\omega C_B}} V_C \quad \frac{V_o}{V_C} = \frac{R_D}{R_D + \frac{1}{j\omega C_B}} = \frac{j\omega R_D C_B}{1 + j\omega R_D C_B} \Rightarrow V_C = \frac{V_B \cdot R_C}{R_B} + V_B = 4.03 V_B$$

$$\frac{V_o}{V_C} \cdot \frac{V_B}{V_i} \Rightarrow \frac{V_o}{4.03 V_B} \cdot \frac{V_B}{V_i} \Rightarrow \frac{V_o}{4.03 V_i} = \frac{j\omega R_D C_B}{1 + j\omega R_D C_B} \cdot \frac{4.03}{1 + j\omega R_A C_A}$$

$$H(s) = \frac{(4.03 \cdot R_D C_B) \cdot j\omega}{\left(1 + j\frac{\omega}{\frac{1}{R_D C_B}}\right) \cdot \left(1 + j\frac{\omega}{\frac{1}{R_A C_A}}\right)} \Rightarrow \frac{0.00109 \cdot j\omega}{\left(1 + j\frac{\omega}{370.37}\right) \cdot \left(1 + j\frac{\omega}{37037}\right)}$$

① $(0.00109)jw$ ②

③ $\frac{}{(1+j\frac{w}{37037})(1+j\frac{w}{37037})}$ ④

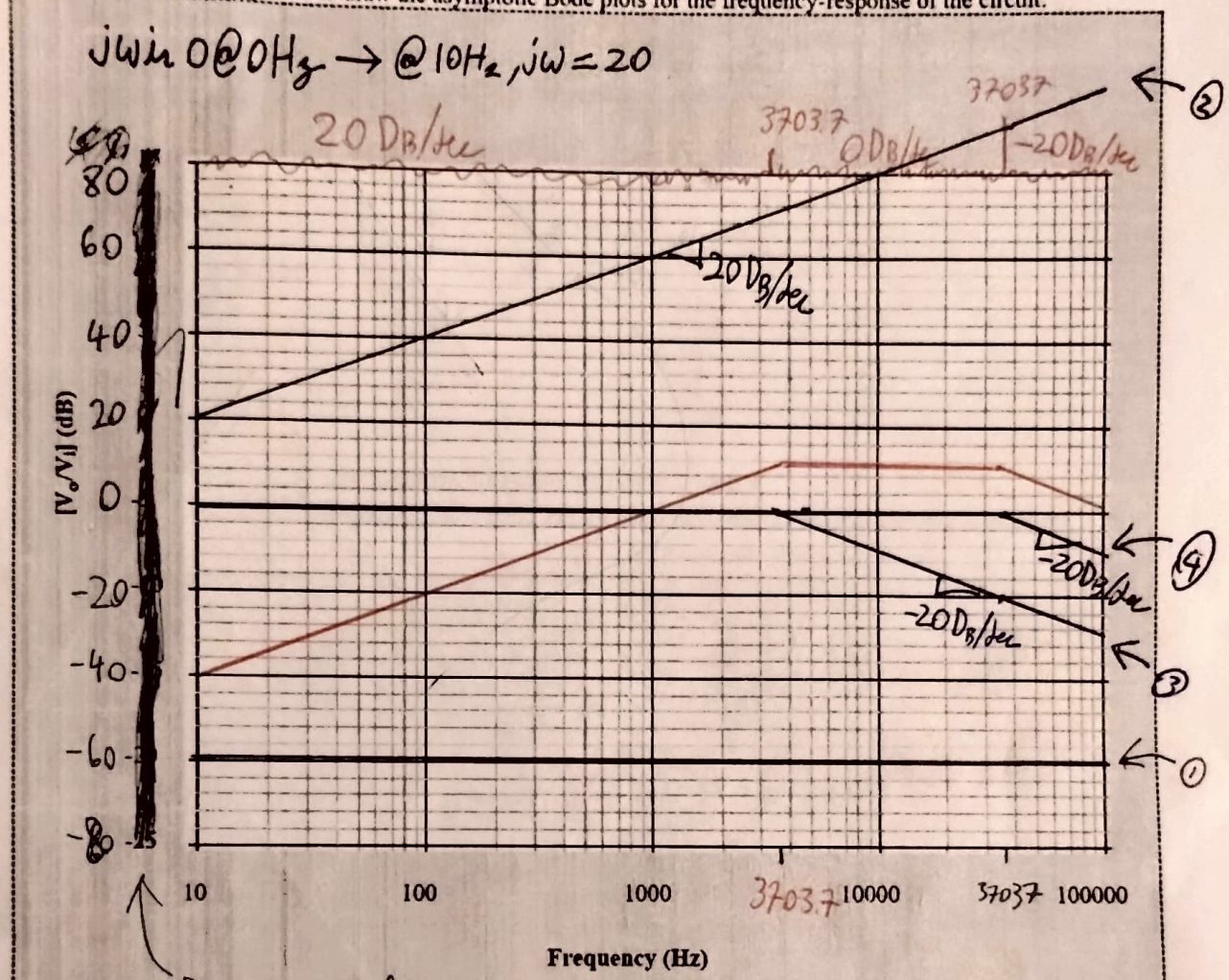
① $20\log(0.00109) = -59.25$ ——

② jw constant slope 20 DB/dec ——

③ ——

④ —— final ——

ii) Use **Graph 2.0** to draw the asymptotic Bode plots for the frequency-response of the circuit:



Graph 2.0 (*Gain*)

constant term = 0

① $jw = 90°$

② = ——— find —

③ = ———

$$\frac{(0.00109)\cdot jw \;①}{② \;(1+j\frac{w}{3703.7})(1+j\frac{w}{37037})\;③}$$

$$\frac{1}{(1+j\frac{w}{3703.7})}$$

370.37 → 0°

3703.7 → -45°

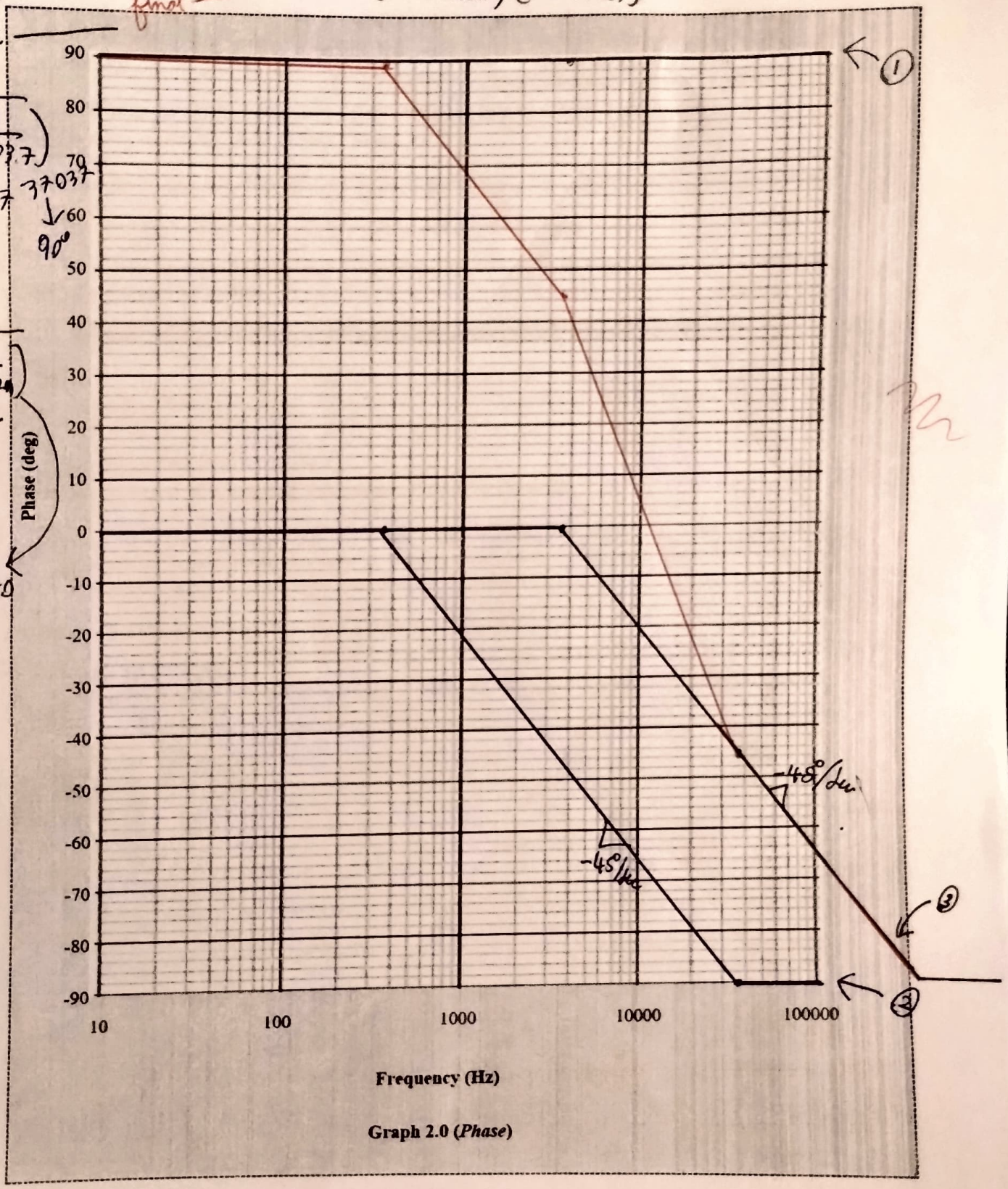
37037 → -90°

$$\frac{1}{(1+j\frac{w}{370370})}$$

37037 → 0°

37037 → -45°

370370 → -90°



Graph 2.0 (*Phase*)

iii) Use Multisim to plot the magnitude in dB and phase in degrees of the frequency-responses of the above circuits, for $10Hz \leq f \leq 100kHz$. (Note: Simulate->Instruments->Bode Plotter can be used in creating the plots).

Pre-Lab workspace (show your analysis here)