Matric No.: | | Section: | |
Name: | |

الجامعة الإسلامية العالمية ماليزيا
INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA
يونيبرسيتي إسلام انتارابغسا مليسيا

KULLIYYAH OF ENGINEERING

MIDTERM EXAMINATION
SEMESTER I, 2022/2023 SESSION

MODEL ANSWER

Programme	: **Engineering**	Level of Study	: **UG 2**
Time	: **8:00 pm - 10:00 pm**	Date	: **09/12/2022**
Duration	: **2 Hrs**		
Course Code	: **EECE 2313**	Section(s)	: **1-3**
Course Title	: **Electronic Circuits**		

This Question Paper Consists of **10 (Ten)** Pages (Including Cover Page) with **4 (Four)** Questions.

INSTRUCTION(S) TO CANDIDATES

- Total mark of this examination is **25**.
- This examination is worth **25%** of the total course assessment.
- Answer **ALL QUESTIONS**.
- Marks assigned to each problem are listed in the margins.
- Write your answer on the question paper, no additional page will provid.
- Write your answer using pen, however you can use a pencil for drawing the figure.

Q1 [7]		Q2 [7]		Q3 [6]		Q4 [5]
(a) [4]	(b) [3]	(a) [4]	(b) [3]	(a) [3]	(b) [3]	[5]

Question 1 [7 marks]

(a) Derive the voltage transfer function step by step for the *RC*-circuit shown in **Fig. 1 (a)** as standard format. **(4 marks)**

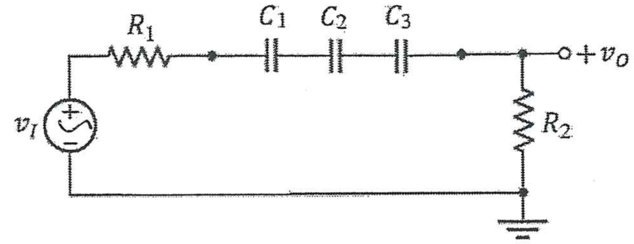
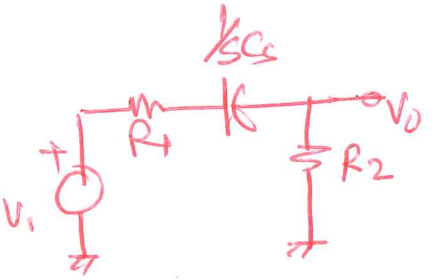


Fig. 1(a)

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$



$$Z_s = R_1 + \frac{1}{sC_s}$$

$$Z_p = R_2$$

$$Z_s + Z_p = R_1 + R_2 + \frac{1}{sC_s} = \frac{(R_1+R_2)sC_s + 1}{sC_s}$$

$$\therefore \quad T(s) = \frac{Z_p}{Z_s+Z_p} = \frac{R_2 sC_s}{1 + sC_s(R_1+R_2)}$$

$$= \frac{R_2}{(R_1+R_2)} \cdot \frac{sC_s(R_1+R_2)}{1 + sC_s(R_1+R_2)}$$

$$= \frac{R_2}{R_1+R_2} \cdot \frac{s\tau_s}{1+s\tau_s} \qquad \tau_s = \underline{C_s(R_1+R_2)}$$

(b) Assumne that the circuit components of **Fig. 1(b)** are $R_1 = 5\ \text{k}\Omega,\ R_2 = 2.5\ \text{k}\Omega,$ $C_1 = 8\ \text{pF},\ C_2 = 5\ \text{pF}$ and $C_2 = 15\ \text{pF}$ respectively. **(3 marks)**

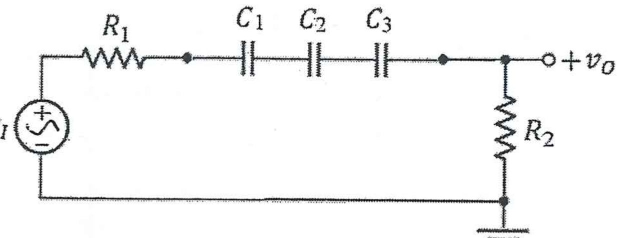


Fig. 1(b)

i. Determine the -3dB corner frequency of the circuit

ii. Determine the magnitude of the transfer function at -3dB corner frequency

iii. Determine the phase of the transfer function at -3dB corner frequency

$$\frac{1}{C_s} = 1/C_1 + \frac{1}{C_2} + \frac{1}{C_3} \Rightarrow C_s = \left(8^{-1} + 5^{-1} + 15^{-1}\right)^{-1}$$

$$= 2.553\ \text{pF}$$

$$R_{eq} = (5+2.5)_k = 7.5K$$

(a) $$f_{3dB} = \frac{1}{2\pi R_{eq} \times C_s}$$

$$= \frac{1}{2\pi\, 7.5K \times 2.553\ \text{pF}} = 8.31\ \text{MHz}$$

$$\omega_c = \frac{1}{\tau_s}$$

$$T(S) = \frac{R_2}{R_1+R_2} \cdot \frac{s\tau}{1+s\tau} = \frac{R_2}{R_1+R_2} \cdot \frac{j\omega\tau_s}{1+j\omega\tau_s}$$

$$|T(S)|_{\omega=\omega_c} = \frac{R_2}{R_1+R_2} \cdot \left(\frac{j1}{1+j1}\right)$$

$$|T(S)|_{\omega=\omega_c} = \frac{R_2}{R_1+R_2} \cdot \frac{1}{\sqrt{2}} = \frac{2.5}{5+2.5} * \frac{1}{\sqrt{2}} = 0.235$$

$$= -12.55\ \text{dB}$$

$$\angle\theta_{\omega=\omega_c} = (90-45^\circ) = 45^\circ$$

Question 2 [7 marks]

(a) Plot the Bode magnitude and phase for the following transfer function. **(4 marks)**

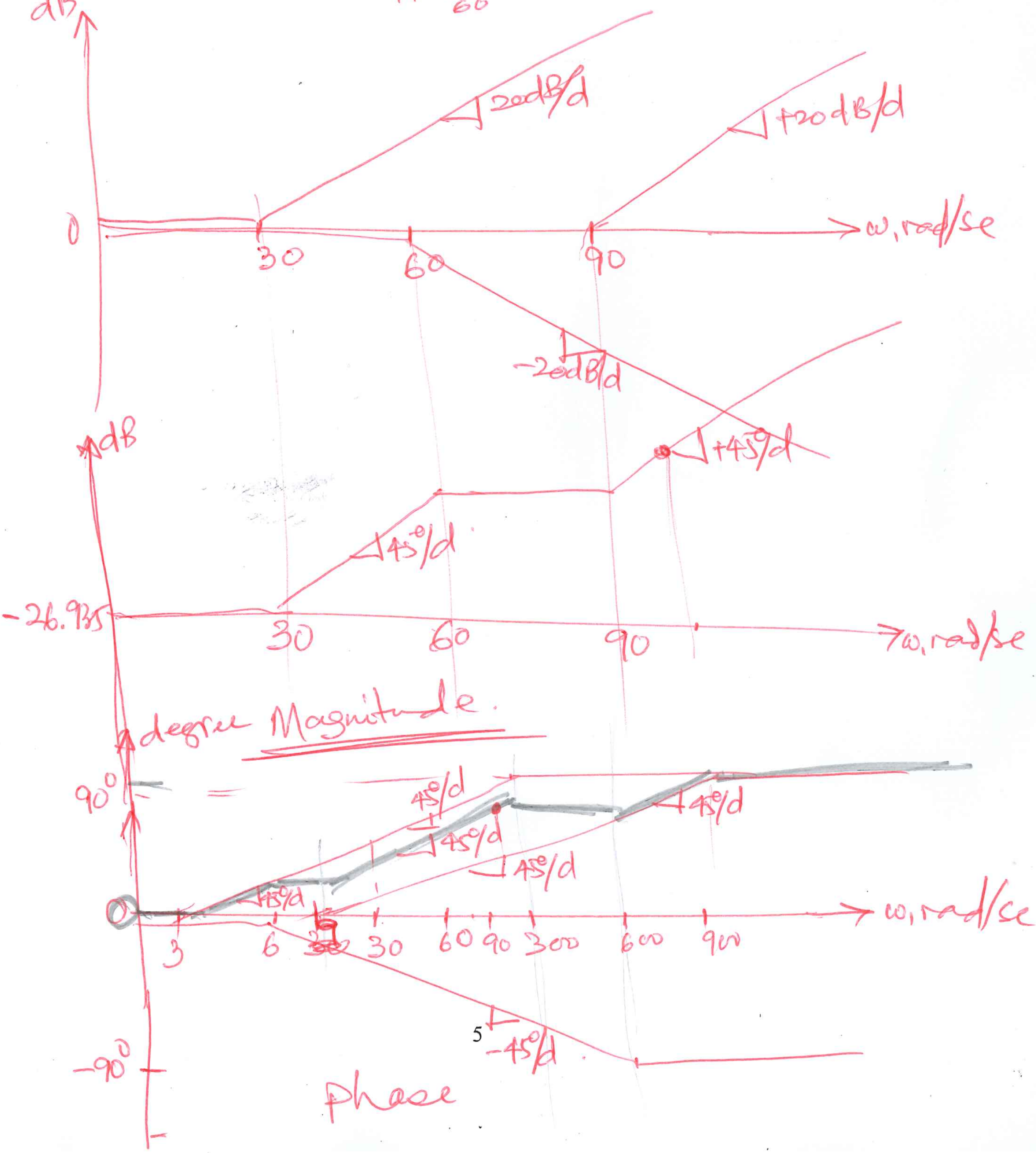
$$T(s) = \frac{10^{-3}(s+30)\,(s+90)}{(s+60)}$$

(b) Determine the magnitude and phase at angular frequency 100 rad/sec. **(3 marks)**

$$T(s) = 10^{-3} \times \frac{30 \times 90}{60} \frac{\left(1+\frac{s}{30}\right)\left(1+\frac{s}{90}\right)}{\left(1+\frac{s}{60}\right)}$$

$$= 45 \times 10^{-3} \frac{\left(1+s/30\right)\left(1+s/90\right)}{1+\frac{s}{60}}$$

$$T(s)\big|_{dB} = 20 \log_{10} 45 \times 10^{-3} = -26.935\,dB$$



$\omega = 100\ rad/sec$

Magnitude

$$\left|T\right|_{\omega_{100}} = 45\times10^{-3} \times \left| \frac{\frac{\cancel{s}}{30}\ \frac{\cancel{s}}{90}}{\frac{\cancel{s}}{60}} \right|$$

$$= \frac{45\times10^{-3}}{45}\left|s\right| = \frac{45\times10^{-3}}{\cancel{45}} \times 100 = 0.1$$

$$T\Big|_{dB_{100}} = -20\ dB$$

Phase.

$$\theta = \tan^{-1}\frac{\omega}{30} + \tan^{-1}\frac{\omega}{90} - \tan^{-1}\frac{\omega}{60}$$

$$= \tan^{-1}\frac{100}{30} + \tan^{-1}\frac{100}{90} - \tan^{-1}\frac{100}{60}$$

$$= 73.3 + 48.01 - 59.03$$

$$= 62.27^{\circ}$$

Question 3 [6 marks]

The common emitter amplifier is shown in **Fig. 3** with the following circuit component values $R_S = 1.4\ \mathrm{k\Omega}$, $R_1 = 32\ \mathrm{k\Omega}$, $R_E = 0.5\ \mathrm{k\Omega}$, $R_C = 4\ \mathrm{k\Omega}$, $R_L = 5\ \mathrm{k\Omega}$ and $C_{C2} = \infty$. The BJT has AC small-signal hybrid-π parameters, $g_m = 15\ \mathrm{mA/V}$, $r_\pi = 4\ \mathrm{k\Omega}$ and $r_0 = \infty$.

(a) Design the amplifier circuit for the lower corner frequency 2 kHz. **(marks 3)**

(b) Draw the small-signal equivalent circuit and determine the maximum gain of the designed amplifier in dB. **(marks 3)**

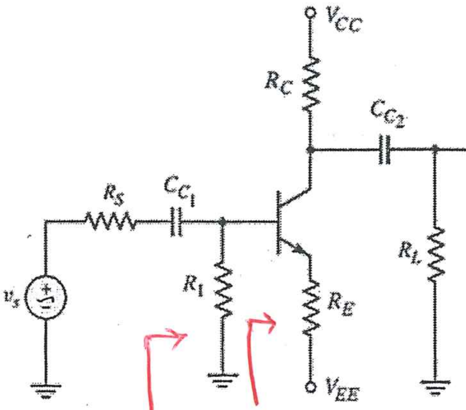


Fig. 3

$\beta = 15 \times 4 = 60$

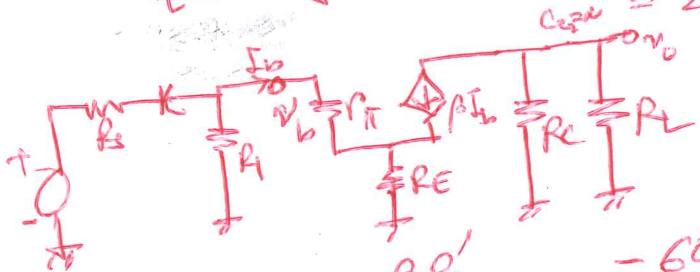
a)

$R_{ib} = r_\pi + (1+\beta) R_E$
$= 4 + (1+60) 0.5 = 34.5$

$R_i' = R_1 \| R_{ib} = 16.6\ \mathrm{K\Omega}$

$f_L = \dfrac{1}{2\pi C_{C1}[R_S + R_i']} \Rightarrow C_{C1} = \dfrac{1}{2\pi f_L \times [R_S + R_i']}$
$= 4.42\ \mathrm{nF}$

(b)



$R_L' = 5 \| 4_k$
$= 2.22\mathrm{K}$

$A_{vA} = \dfrac{v_o}{v_b} = \dfrac{-\beta R_L'}{R_{ib}} = \dfrac{-60 \times 2.22}{34.5} = -3.865$

$A_v = A_{vA} \times \dfrac{R_i'}{R_i' + R_S} = -3.865 \times \dfrac{16.6}{16.6 + 1.4}$
$= -3.56$

$A_v|_{dB} = 20 \log_{10}(3.56) = 11.039\ \mathrm{dB}$

Question 4 [5 marks]

The common source amplifier is shown in **Fig. 4**. Assume that the MOSFET has small-signal high-frequency parameters, $g_m = 20$ mA/V, $r_o = 25$ kΩ, $C_{gs} = 12$ pF and $C_{gd} = 1.5$ pF. Draw the Miller equivalent circuit and determine the -3dB higher corner frequency considering the miller capacitance effect. **(5 marks)**

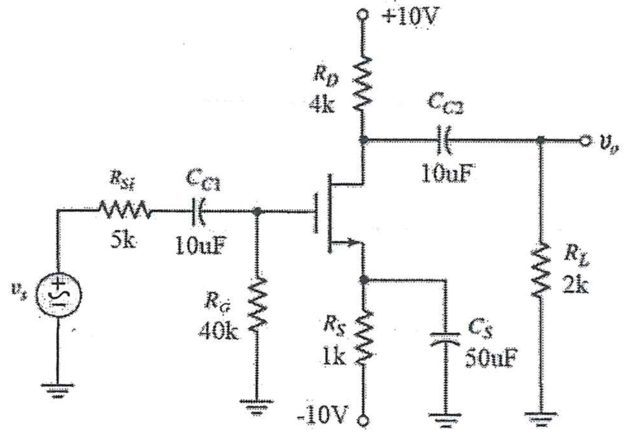
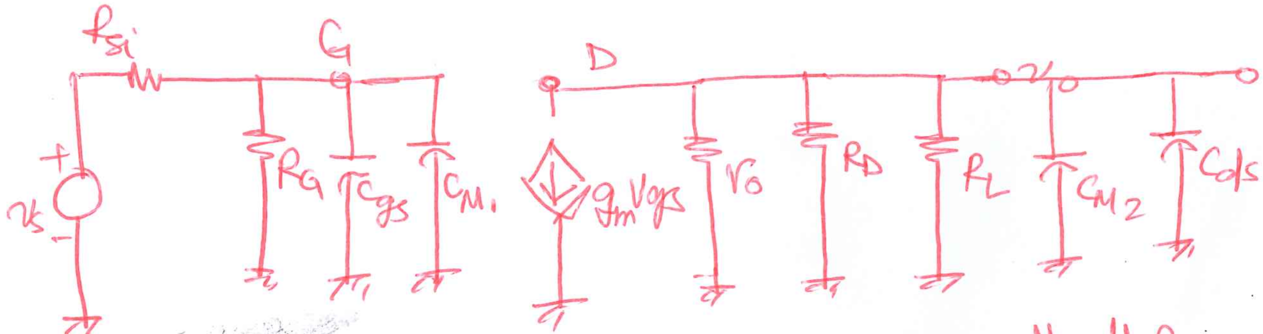


Fig. 4

$R_L' = r_o \| R_D \| R_L$
$= 1.2658 k\Omega$



$C_{M_1} = C_{gd}\left[1 + |A_{VA}|\right]$

$A_{VA} = -\dfrac{g_m V_{gs} \; r_o \| R_D \| R_L}{V_{gs}}$
$= -g_m \; r_o \| R_D \| R_L$
$= -25.316$

$C_{M_1} = 1.5p\left[1 + 25.316\right] = 39.47\ pF$

$C_T = C_{gs} + C_{M_1} = 51.4747\ pF.$

$R_{si} \| R_G = 5K \| 40K$
$= 4.44K$

$f_H = \dfrac{1}{2\pi\, R_{si} \| R_G \times C_T}$

$= \dfrac{1}{2\pi \times 4.44K \times 51.4747pF} = 695.67\ KHz$