REG.NO.:

VIT

Vellore Institute of Technology

SCHOOL OF ELECTRICAL ENGINEERING
CONTINUOUS ASSESSMENT TEST - II
WINTER SEMESTER 2024-2025

SLOT: C2

Programme Name & Branch	: B.Tech. EEE & EIE
Course Code and Course Name	: BEEE205L - Electronic Devices and Circuits
Faculty Name(s)	: Dr. N. Sudhakar & Dr. G. Arunkumar
Class Number(s)	: VL2025260101212 & VL2025260101213
Date of Examination	: 07-10-2025, Tuesday, 09.30 AM to 11.00 AM
Exam Duration	: 90 minutes

Maximum Marks: 50

General instruction(s):

- Answer All Questions
- M - Max mark; CO – Course Outcome; BL – Blooms Taxonomy Level (1 – Remember, 2 - Understand, 3 – Apply, 4 – Analyse, 5 – Evaluate, 6 – Create)
- Course Outcomes (**Type the CO statements covered in this question paper. Use the CO number as per the syllabus copy)**

  CO2 – Analyze and design BJT and MOSFET DC circuits and their amplifier configurations

Q. No	Question	M	CO	BL
1.	Design and analyze a BJT Common-Emitter Voltage Divider Biased (CE-VDB-with full bypass capacitor) amplifier using the following parameters: V_{CC} = 20 V, β = 200, R_1 = 180 kΩ, R_2 = 27 kΩ, R_E = 1.0 kΩ with full bypass capacitor C_E = 470 µF, R_C = 3.9 kΩ, Source resistance R_S = 600 Ω (in series with AC input), Load resistance R_L = 10 kΩ, Coupling capacitors: C_{in} = 4.7 µF, C_{out} = 10 µF. Task: Determine the AC output voltage v_{out} for a sinusoidal input v_{in} = 10 mV. Clearly show: 1. DC bias point calculations 2. AC small-signal model parameters 3. Final voltage gain and output voltage.	10	2	3
2.	Design and analyze a BJT Common-Emitter Voltage Divider Biased (CE-VDB-no bypass capacitor) amplifier using the following parameters: V_{CC} = 18 V, β = 180, R_1 = 150 kΩ, R_2 = 33 kΩ, R_E = 1.2 kΩ (no bypass capacitor), R_C = 4.7 kΩ, Load resistance R_L = 6.8 kΩ, Coupling capacitors: C_{in} = 3.3 µF, C_{out} = 10 µF. Assume V_{BE} = 0.7 V, V_T = 25 mV. Task: For a sinusoidal input, v_{in} = 15 mV, determine the AC output voltage v_{out}. Clearly show: 1. DC bias point calculations 2. AC small-signal model parameters 3. Final voltage gain and output voltage	10	2	3
3.	Design and analyze a BJT Common-Emitter Voltage Divider Biased (CE-VDB-swamped) amplifier using the following parameters: V_{CC} = 18 V, β = 180, R_1 = 150 kΩ, R_2 = 27 kΩ, R_{E1} = 47 Ω (unbypassed), R_{E2} = 1 kΩ parallel with C_E = 220 µF (bypassed for AC), R_C = 4.3 kΩ, Source resistance	10	2	3

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	R_S = 600 Ω (in series with AC input), Load resistance R_L = 8.2 kΩ, Coupling capacitors: C_{in} = 3.3 μF, C_{out} = 6.8 μF. Assume V_{BE} = 0.7 V, V_T = 25 mV. Task: For a sinusoidal input, v_{in} = 12 mV, determine the AC output voltage v_{out}. Clearly show: 1. DC bias point calculations 2. AC small-signal model parameters 3. Final voltage gain and output voltage.			
4.	Perform a DC operating-point (Q-point) analysis of the N-channel Enhancement MOSFET (E-MOSFET) circuit. The MOSFET source is grounded (no source resistance). A voltage divider biases the gate. V_{DD} = 12 V, R_1 = 1MΩ (to $+V_{DD}$), R_2 = 270 kΩ (to ground), R_D = 2.2 kΩ, V_{Th} = 1.6 V, Transconductance parameter: k = 2.0 mA/V². Assume ideal gate current I_G = 0 A. Task (show all steps & equations): 1. Compute the gate voltage V_G and V_{GS} (note: V_S=0) 2. Compute the drain current I_D and V_{DS} 3. Device power $P_D = I_D * V_{DS}$.	10	2	3
5.	Perform a DC operating-point (Q-point) analysis of the N-channel Enhancement MOSFET (E-MOSFET) circuit. The MOSFET source is connected to the ground through R_s. A voltage divider biases the gate. V_{DD} = 15 V, R_1 = 820 kΩ (to $+V_{DD}$), R_2 = 220 kΩ (to ground), R_D = 3.9 kΩ, R_s = 470 Ω, V_{Th} = 2 V, Transconductance parameter: k = 1.5 mA/V². Assume ideal gate current I_G = 0 A. Task (show all steps & equations): 1. Compute the gate voltage V_G from the divider, and hence V_{GS} 2. Compute the drain current I_{DQ} and V_{GSQ} 3. Find V_{DS}.	10	2	3

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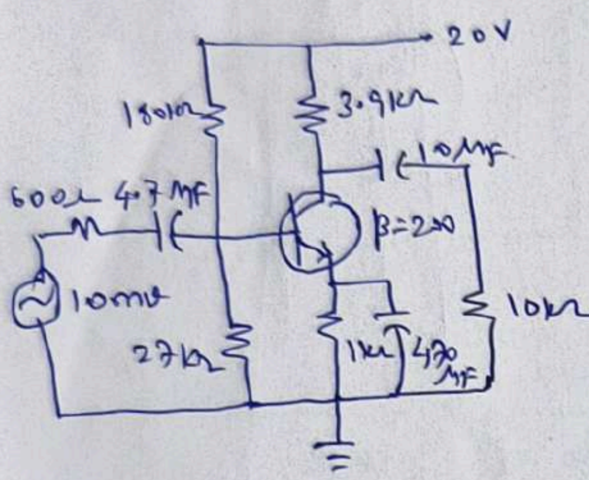
Fall-Sem - 25-26 C_2-slot:

BEEE205L - EDC Key:

(1) $V_{cc} = 20V$, $\beta = 200$, $R_1 = 180k\Omega$, $R_2 = 27k\Omega$, $R_E = 1k\Omega$, $C_E = 470\mu F$

$R_C = 3.9k\Omega$, $R_S = 600\Omega$, $R_L = 10k\Omega$, $C_{in} = 4.7\mu F$, $C_0 = 10\mu F$, $V_{in} = 10mV$



$$V_{th} = \frac{V_{cc} \cdot R_2}{R_1 + R_2} = \frac{(20)(27K)}{(180K + 27K)} = 2.608V.$$

$$R_{th} = R_1 \| R_2 = 180K \| 27K = 23.478 k\Omega$$

βR_E $\quad 10 R_2$

$(200)(1K) < 10(27K)$; $\beta \neq 1+\beta$.

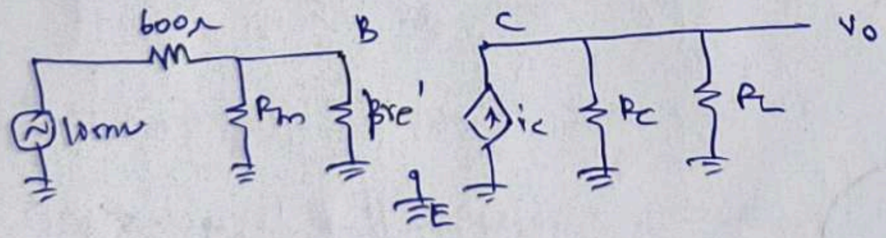
$I_C \neq I_E$.

$$I_B = \frac{V_{th} - V_{BE}}{R_{th} + (1+\beta)R_E} = \frac{2.608 - 0.7}{(23.478K) + (200+1)(1K)} = 8.499\mu A.$$

$$I_C = \beta I_B = (200)(8.499\mu A) = 1.699 mA.$$

$$I_E = (1+\beta) I_B = (201)(8.499\mu A) = 1.708 mA.$$

$$r_e' = \frac{26mV}{I_E} = \frac{26mV}{1.708mA} = 15.222\Omega, \quad \beta r_e' = (200)(15.222) = 3.044k\Omega$$



$$Z_i(base) = \beta r_e' = 3.044k\Omega$$

$$Z_i(stage) = R_{th} \| \beta r_e' = 23.478K \| 3.044K = 2.694k\Omega$$

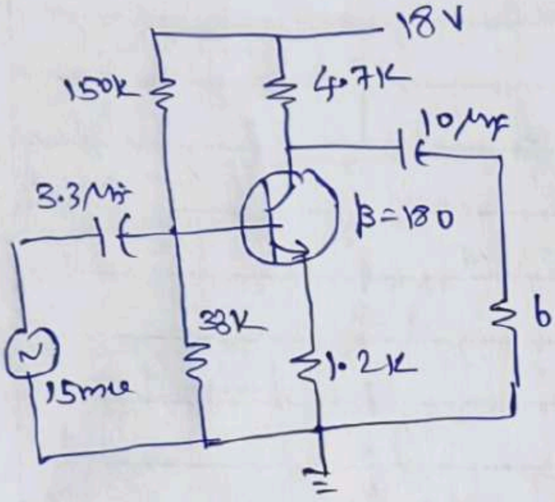
$$r_c = R_C \| R_L = 3.9K \| 10K = 2.805k\Omega$$

$$V_i = \frac{V_s \cdot Z_i(stage)}{R_s + Z_i(stage)} = \frac{(10m)(2.694K)}{600 + (2.694K)} = 8.153mV$$

$$A_V = \frac{r_c}{r_e'} = \frac{2.805K}{15.222} = 184.272, \quad V_o = A_V \cdot V_i = 1.502V.$$

② $V_{CC} = 18V$, $\beta = 180$, $R_1 = 150k\Omega$, $R_2 = 33k\Omega$, $R_E = 1.2k\Omega$, $R_C = 4.7k\Omega$

$R_L = 6.8k\Omega$, $C_{in} = 3.3\mu f$, $C_o = 10\mu f$, $V_{BE} = 0.7V$, $V_T = 25mV$, $V_{in} = 15mV$



$$V_{th} = \frac{V_{CC} \cdot R_2}{R_1 + R_2} = \frac{(18)(33K)}{150K + 33K} = 3.245V$$

$$R_{th} = R_1 \| R_2 = 150K \| 33K = 27.049\,k\Omega$$

$\beta R_E \quad 10R_2$

$(180)(1.2k) < 10(33K)$; $\beta \neq 1+\beta$

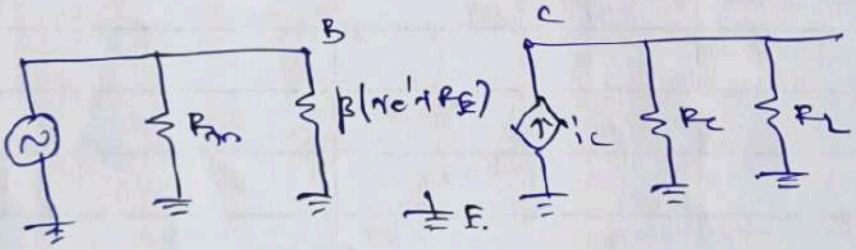
$I_C \neq I_E$.

$$I_B = \frac{V_{th} - V_{BE}}{R_{th} + (1+\beta)R_E} = \frac{3.245 - 0.7}{(27.049K) + (181)(1.2K)} = 10.419\,\mu A.$$

$I_C = \beta I_B = (180)(10.419\mu A) = 1.875$ mA.

$I_E = (1+\beta) I_B = (181)(10.419\mu A) = 1.885$ mA.

$$r_e' = \frac{V_T}{I_E} = \frac{25mV}{1.885mA} = 13.262\,\Omega, \quad \beta(r_e' + R_E) = 218.387\,k\Omega$$



$Z_{i(base)} = \beta(r_e' + R_E) = 218.387\,k\Omega$

$Z_{i(stage)} = R_{th} \| Z_{i(base)} = 27.049k \| 218.387K = 24.067\,k\Omega$

$r_c = R_C \| R_L = 4.7K \| 6.8K = 2.779\,k\Omega$

$V_i = 15mV$

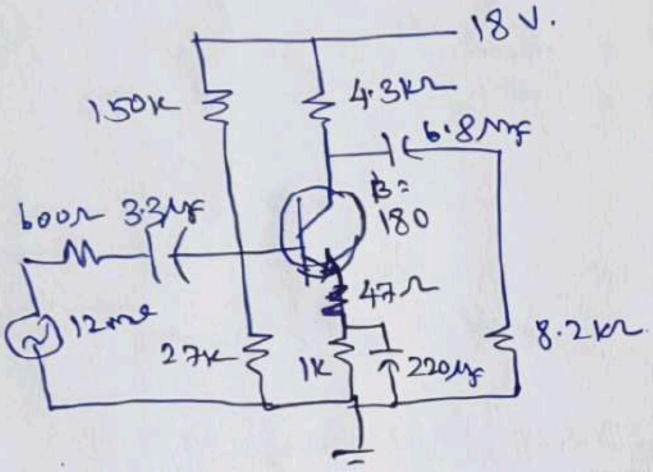
$$A_V = \frac{r_c}{r_e + R_E} = \frac{2.779k}{(13.262 + 1200)} = 2.29$$

$\therefore V_o = A_V \cdot V_i = (15mV)(2.29) = 34.35\,mV.$

(3) $V_{CC} = 18V$, $\beta = 180$, $R_1 = 150k\Omega$, $R_2 = 27k\Omega$, $R_{E_1} = 47\Omega$, $R_{E_2} = 1k\Omega$,

$C_E = 220\mu F$, $R_C = 4.3k\Omega$, $R_S = 600\Omega$, $R_L = 8.2k\Omega$, $C_{in} = 3.3\mu F$,

$C_O = 6.8\mu F$, $V_{BE} = 0.7V$, $V_T = 25mV$, $V_{in} = 12mV$



$$V_{th} = \frac{V_{CC} \cdot R_2}{R_1 + R_2} = \frac{(18)(27k)}{150k + 27k} = 2.745V$$

$$R_{th} = R_1 \| R_2 = 150k \| 27k = 22.881k\Omega$$

$\beta R_E \quad 10 R_2$

$(180)(1047) < (10)(27k)$

$\therefore \beta \neq 1 + \beta$, $I_C \neq I_E$

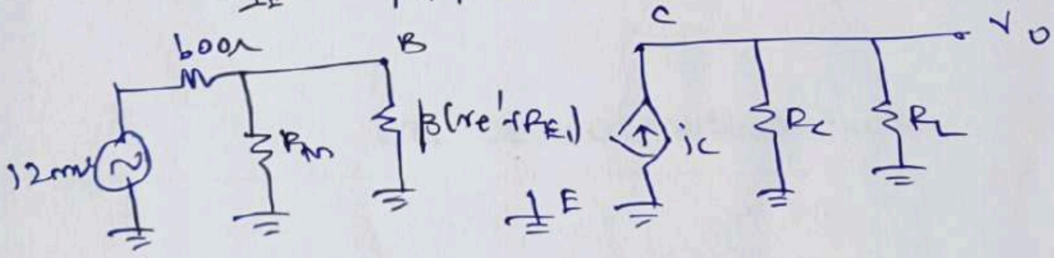
$R_E = R_{E_1} + R_{E_2} = 1047\Omega$

$$I_B = \frac{V_{th} - V_{BE}}{R_{th} + (1+\beta) R_E} = \frac{2.745 - 0.7}{22.881k + (181)(1.047k)} = 9.628 \mu A$$

$$I_C = \beta I_B = (180)(9.628 \mu A) = 1.733 mA.$$

$$I_E = (1+\beta) I_B = (181)(9.628 \mu A) = 1.742 mA.$$

$$r_e' = \frac{V_T}{I_E} = \frac{25mV}{1.742mA} = 14.351\Omega, \quad \beta(r_e' + R_{E_1}) = (180)(61.351) = 11.043k\Omega$$



$$Z_i(base) = \beta(r_e' + R_{E_1}) = 11.043k\Omega$$

$$Z_i(stage) = R_{th} \| Z_i(base) = 22.881k \| 11.043k = 7.448k\Omega$$

$$r_c = R_c \| R_L = 4.3k \| 8.2k = 2.82k\Omega$$

$$v_i = \frac{V_S \cdot Z_i(stage)}{R_S + Z_i(stage)} = \frac{(12m)(7.448k)}{(600 + 7.448k)} = 11.105mV,$$ ~~$A_V = \frac{r_c}{R_{E_1}}$~~

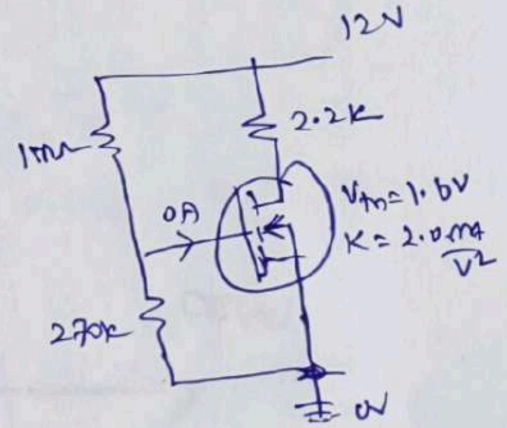
$$A_V = \frac{r_c}{r_e' + R_E} = \frac{2.82k}{11.043k} = 0.255, \quad V_o = A_V \cdot v_i = (0.255)(11.105m) = 2.831m$$

④ $V_{DD} = 12\,V$, $R_1 = 1M\Omega$, $R_2 = 270k\Omega$, $R_D = 2.2k\Omega$, $V_{tn} = 1.6\,V$,

$K = 2.0\; mA/V^2$, $I_G = 0A$.

Dc. Analysis: $R_S = 0\,\Omega$.

$$V_{G_Q} = V_{GS_Q} = \frac{V_{DD} \cdot R_2}{R_1 + R_2} = \frac{(12)(270k)}{(1M) + (270k)} = 2.551\,V.$$



$K = 2.0\,mA/V^2$

$$I_{DQ} = K\left[V_{GS_Q} - V_{GS(th)}\right]^2$$

$$= (2.0\,mA/V^2)\left[2.551 - 1.6\right]^2$$

$I_{DQ} = 1.808\; mA.$

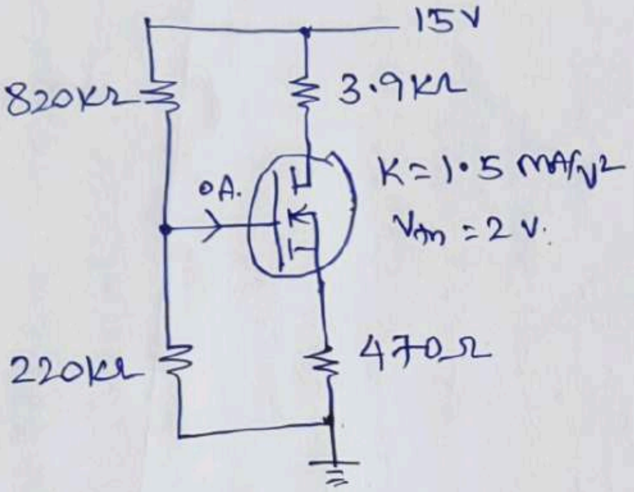
$V_{DS} = V_{DD} - I_{DQ} \cdot R_D$

$= 12 - (1.808\,mA)(2.2K)$

$V_{DS} = 8.022\,V.$

$P_D = I_D \cdot V_{DS} = (1.808m)(8.022) = 14.503\; mW.$

(5) $V_{DD} = 15V$, $R_1 = 820k\Omega$, $R_2 = 220k\Omega$, $R_D = 3.9k\Omega$, $R_S = 470\Omega$, $V_{th} = 2V$, $K = 1.5 mA/V^2$, $I_G = 0A$.



$$V_G = \frac{V_{DD} \cdot R_2}{R_1 + R_2} = \frac{(15)(220k)}{820k + 220k}$$

$$V_G = 3.173V.$$

St. line:

$$V_{GS} = V_G - I_D R_S$$

$$V_{GS} = 3.173 - I_D (470)$$

When $V_{GS} = 0 \Rightarrow I_D = 6.751 mA.$
When $I_D = 0 \Rightarrow V_{GS} = 3.173V$ } St. line points.

Transfer Curve:

$$I_D = K[V_{GS} - V_{GS(th)}]^2$$

$V_{GS} = 2V \Rightarrow I_D = K[2-2]^2 = 0 mA.$

$V_{GS} = 3V \Rightarrow I_D = (1.5 \times 10^{-3})(3-2)^2 = 1.5 mA.$

$V_{GS} = 4V \Rightarrow I_D = (1.5 \times 10^{-3})(4-2)^2 = 6 mA.$

$V_{GS} = 2.5V \Rightarrow I_D = (1.5 \times 10^{-3})(2.5-2)^2 = 0.375 mA$

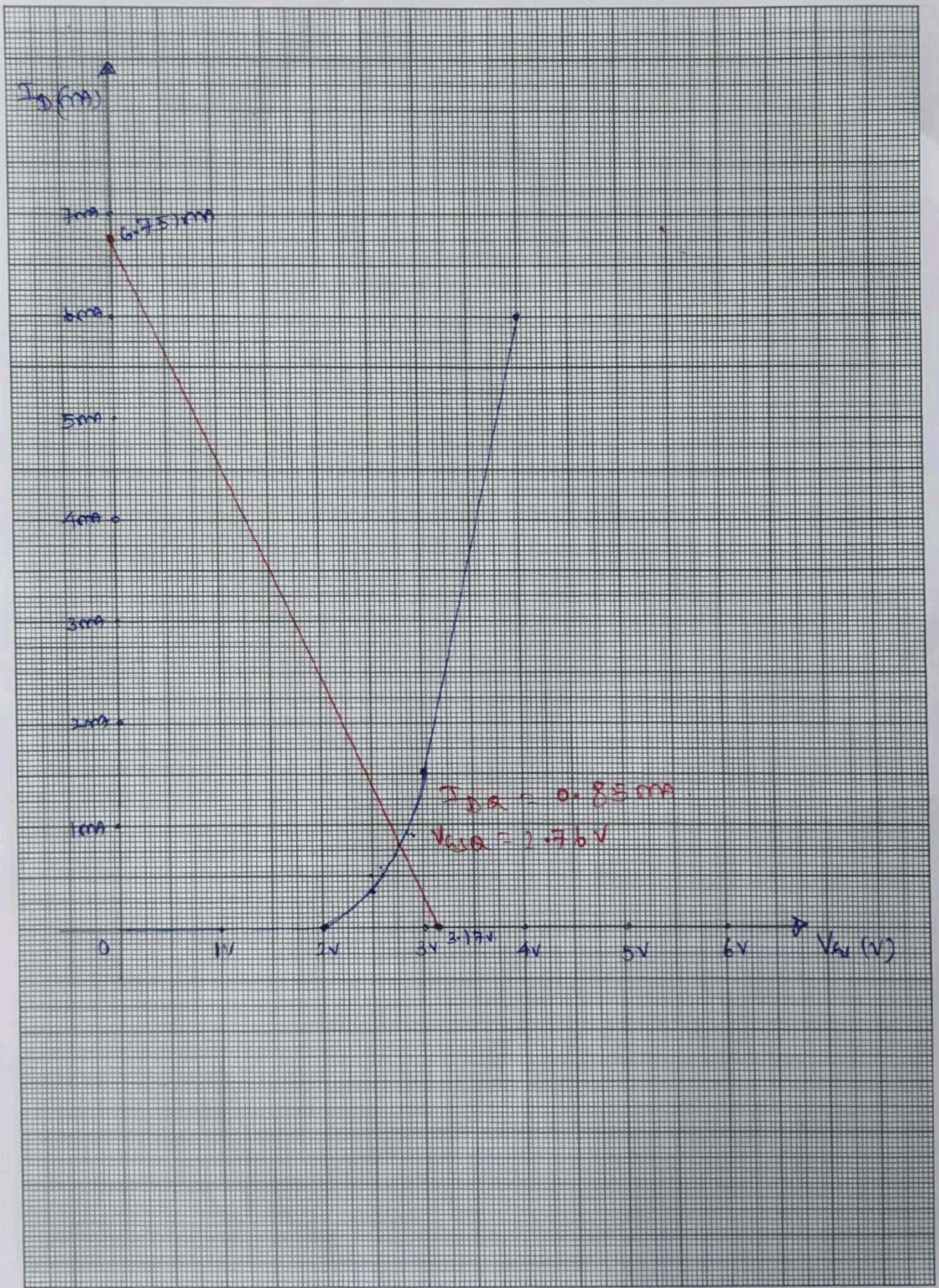
$V_{GS} = 2.6V \Rightarrow I_D = (1.5 \times 10^{-3})(2.6-2)^2 = 0.54 mA.$

$V_{GS} = 2.7V \Rightarrow I_D = (1.5 \times 10^{-3})(2.7-2)^2 = 0.735 mA.$

$V_{GS} = 2.8V \Rightarrow I_D = (1.5 \times 10^{-3})(2.8-2)^2 = 0.96 mA$

From Graph; $I_{DQ} = 0.85 mA$, $V_{GSQ} = 2.76V$.

$$\therefore V_{DS} = V_{DD} - I_{DQ}(R_D + R_S) = 15 - (0.85 mA)(4.37k) = 3.714V$$



I_D (mA)
7mA
6.75mA
6mA
5mA
4mA
3mA
2mA
1mA
0
1V
2V
3V
3.17V
4V
5V
6V
V_{GS} (V)
$I_{DQ} = 0.85$ mA
$V_{GSQ} = 2.76$ V