American International University- Bangladesh (AIUB)
Faculty of Engineering

Course Name :	Electronic Devices	**Course Code:**	EEE 2013
Semester :	Summer 2019-20	**Section:**	N
Faculty :	NOWSHIN ALAM		

Assignment No :	3
Assignment Name :	CO3, CO4 (POI: P.01.4.C3)

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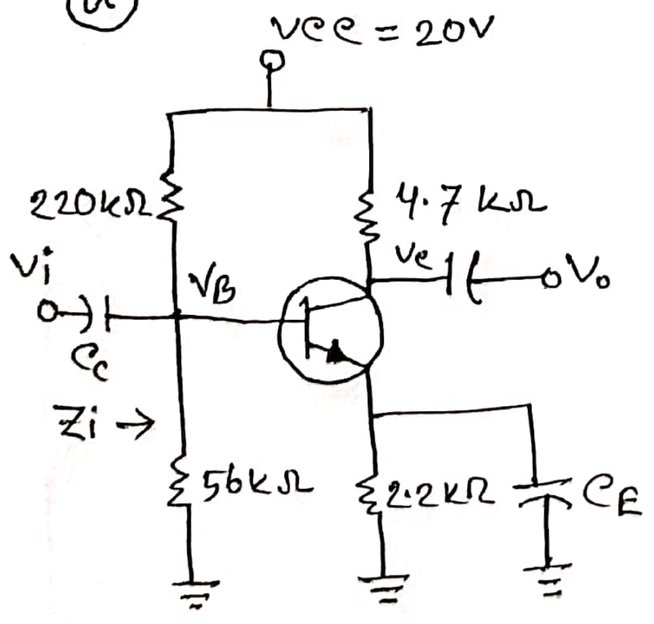
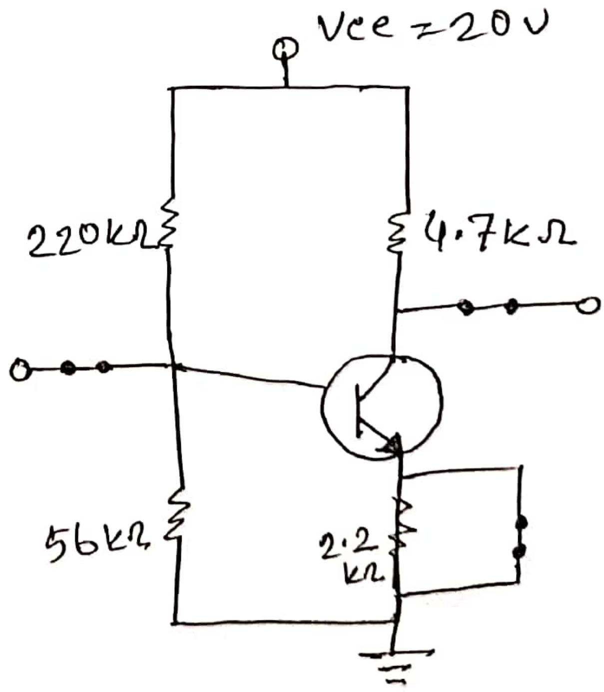
Submission Date:	25.09.2020	**Due Date :**	25-09-2020

Q-1

(a)





$r_o = 38\,k\Omega$

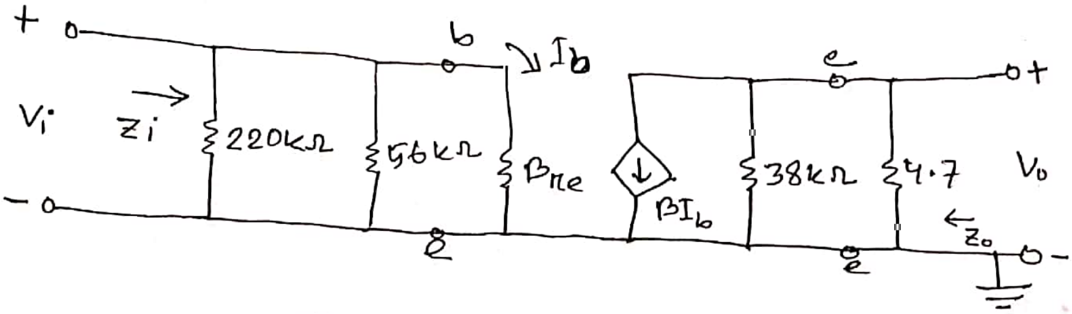


Fig : Ac equivalent circuit

(b)

ID: 19-40338-1

$V_{cc} = 20\,V$

$R_1 = 220\,k\Omega$

$R_2 = 56\,k\Omega$

$R_C = 4.7\,k\Omega$

$R_E = 2.2\,k\Omega$

$\beta = 38 \times 10 = 380$

$r_o = 38\,k\Omega$

DC: Testing $\beta R_E > 10 R_2$

$380 \times 2.2 > 10 \times 56$

$836 > 560$ (satisfied)

using the approximate approch we obtain

$$V_B = \frac{R_2}{R_1 + R_2} V_{cc}$$

$$= \frac{56}{220+56} \times 20$$

$$= 4.057\,V$$

$V_E = V_B - V_{BE} = 4.057 - 0.7 = 3.357\,V$

$I_E = \frac{V_E}{R_E} = \frac{3.357}{2.2} = 1.525\,mA$

$$r_e = \frac{26\,mv}{I_E}$$

$$= \frac{26}{1.625}$$

$$= 17.049\,\Omega$$

ⓒ $R' = R_1 \,||\, R_2$

$$= 200 \,||\, 56$$

$$= \frac{200 \times 56}{200 + 56}$$

$$= 44.637\,k\Omega$$

$$Z_i = R' \,||\, \beta r_e$$

$$= 44.637 \,||\, (380)(17.049)$$

$$= 44.33$$

$$Z_o = R_e \,||\, r_o$$

$$= 4.7 \,||\, 38 = 4.18\,k\Omega$$

$$A_V = \frac{R_e \,||\, r_o}{r_e}$$

$$= \frac{4.18 \times 1000}{17.049}$$

$$= \cancel{0}\,245.18$$

Ans.

Q-2

(a)

$I_{DSS} = 38 mA$

$V_P = -5V$

V_{GS}	$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$
0	38 mA
-1	24.32 mA
-2	13.68 mA
-3	6.08 mA
-4	1.52 mA
-5	0 mA

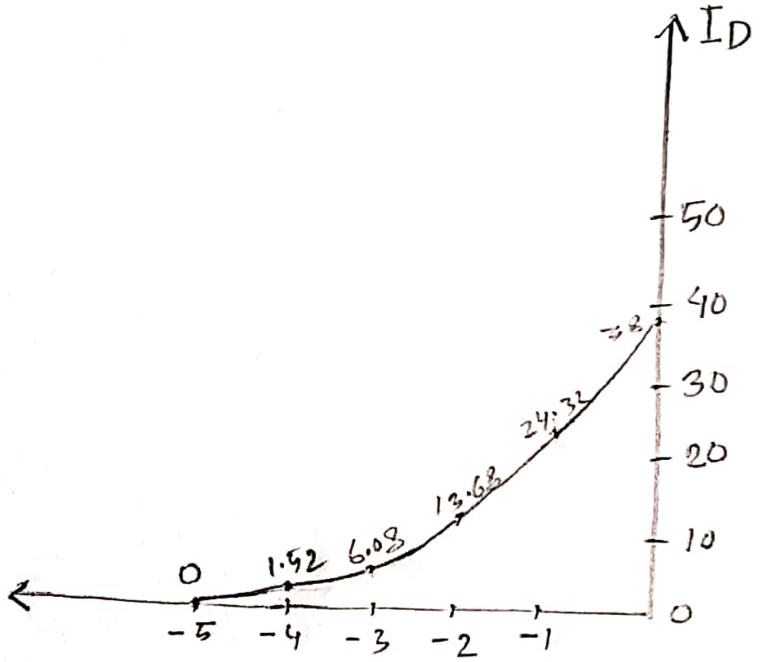


Fig: Transfer characteristic using shorthand method.

(b)

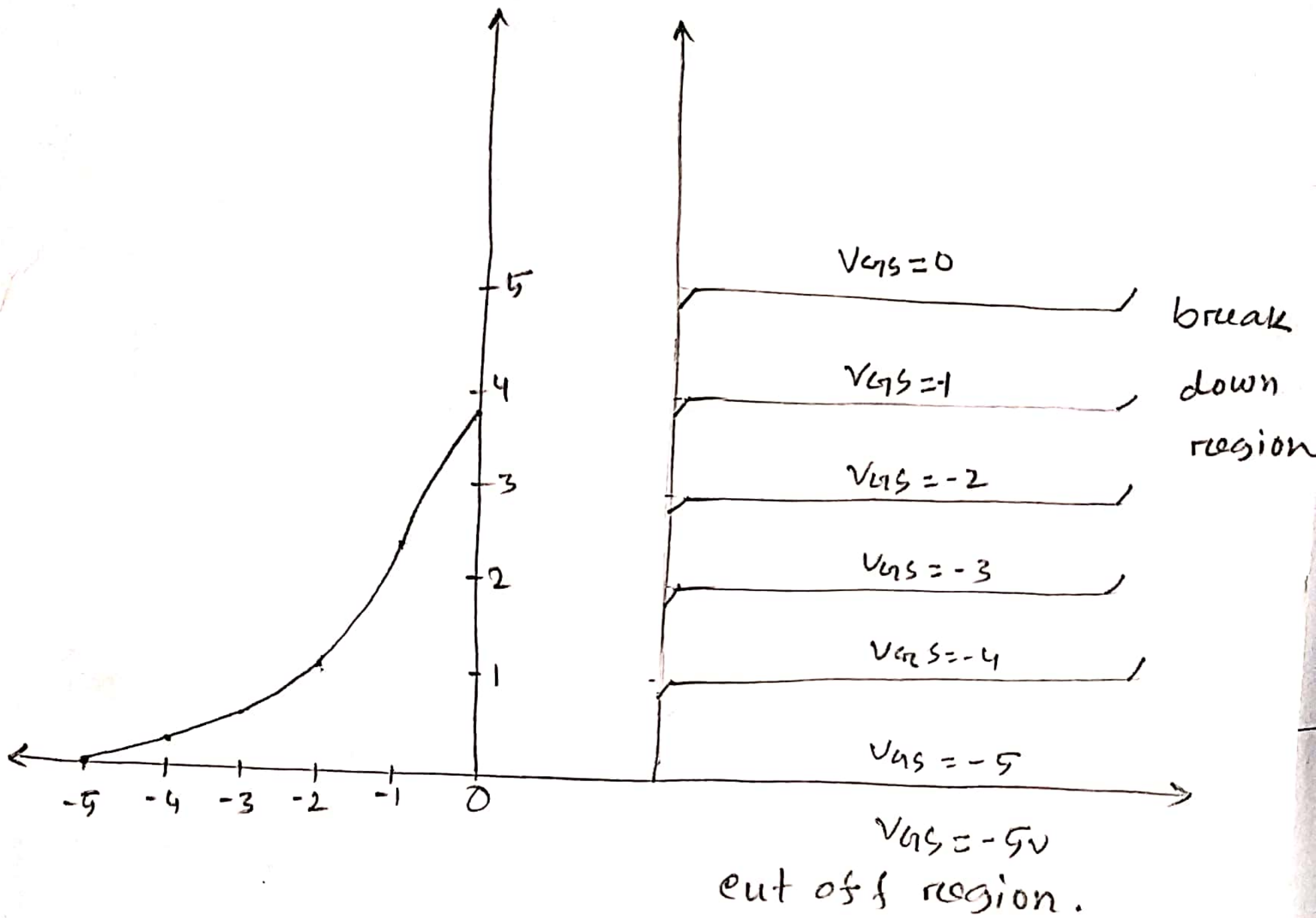


fig: Drain characteristics from the Transfer characteristics.

(c) Max value of gm

$$g_m = \frac{\Delta I_D}{\Delta V_{GS}}$$

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

$$g_m = \frac{-2 I_{DSS}}{V_P}\left(1 - \frac{V_{GS}}{V_P}\right)$$

$$= -g_m\left(1 - \frac{V_{GS}}{V_P}\right)$$

$$g_m = \frac{2 I_{DSS}}{|V_P|}$$

$$= \frac{2 \times 38 \times 10^{-3}}{|V_P|}$$

$$= \frac{2 \times 38 \times 10^{-3}}{|5|}$$

$$= 0.0152 \text{ ohm}^{-1}$$

(d)

From (c)

$$g_m = -\frac{2 I_{DSS}}{V_P}\left(1 - \frac{V_{GS}}{V_P}\right)$$

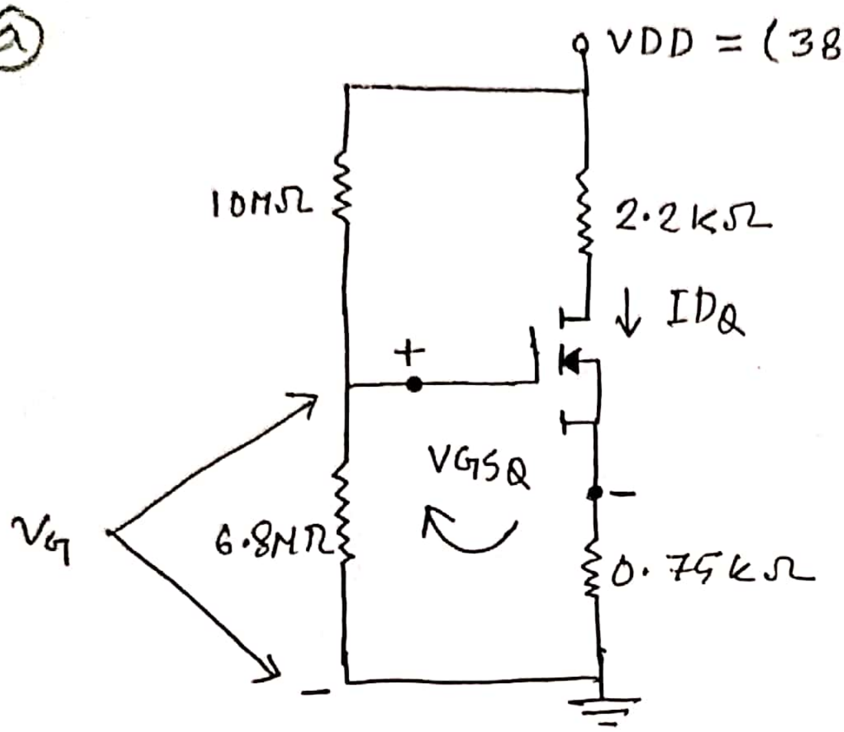
$V_{GS} = -3V$

$$g_m = \frac{-2 \times 38 \times 10^{-3}}{-5}\left(1 - \frac{(-3)}{(-5)}\right)$$

$$= 6.08 \times 10^{-3} \text{ ohm}^{-1}$$

Q-3

(a)



$I_{D(on)} = 5mA$

$V_{GS(on)} = 6V$

$V_{GS(Th)} = 3V$

$R_1 = 10M\Omega$, $R_2 = 6.8M\Omega$

$R_D = 2.2k\Omega$, $R_S = 0.75k\Omega$

$$V_G = \frac{R_2 \times V_{DD}}{R_1 + R_2} = \frac{6.8 \times 23.8}{10 + 6.8} = 9.63\ V$$

Applying KVL

$$V_G - V_{GS} - I_D R_S = 0$$

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

$$V_{GS} = 9.63 - I_D(750) \quad \ldots (1)$$

We know

$$I_D = k(V_{GS} - V_T)^2$$

$$I_D = k(V_{GS} - 3)^2 \quad \ldots (11)$$

Now

$$K = \frac{I_{D(on)}}{(V_{GS(on)} - V_T)^2}$$

$$= \frac{5 \times 10^{-3}}{(6-3)^2}$$

$$= 5.56 \times 10^{-4} \, AV^{-2}$$

From eqn ..(II)

$$I_D = 5.56 \times 10^{-4} (V_{GS} - 3)^2 \, .. \, (III)$$

From eqn (III)

let $V_{GS} = 8V$

$$I_D = 5.56 \times 10^{-4} (8-3)^2$$

$$= 13.9 \, mA$$

let $V_{GS} = 10V$

$$I_D = 5.56 \times 10^{-4} (10-3)^2$$

$$= 27.24 \, mA$$

let $V_{GS} = 12V$

$$I_D = 5.56 \times 10^{-4} (12-3)^2$$

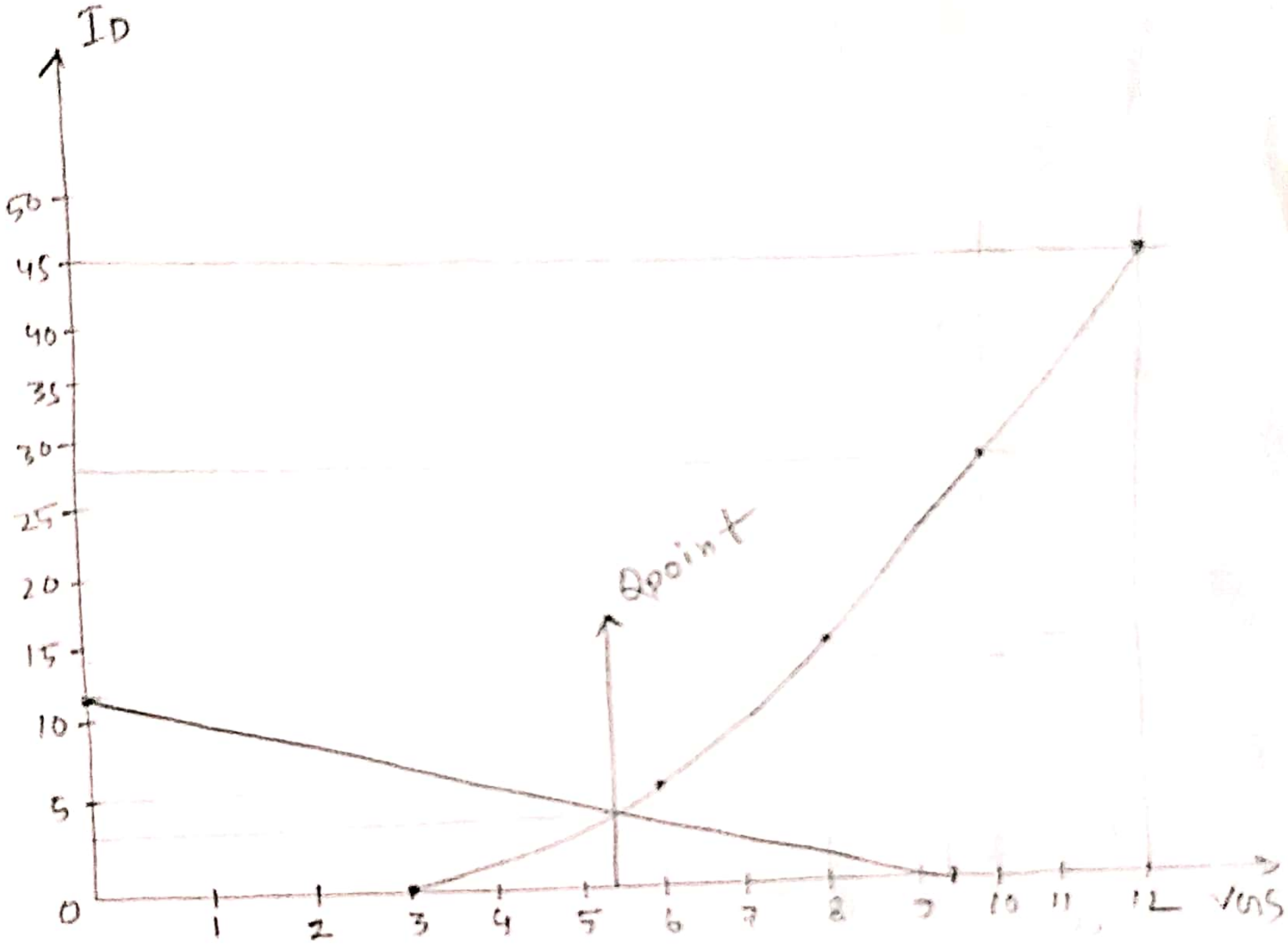
$$= 45.03 \, mA$$

let $V_{GS} = 3V$

$$I_D = 5.56 \times 10^{-4} (3-3)$$

$$= 0$$

The transfer characteristics curve



$I_{DQ} = 3\ mA$

$V_{GSQ} = 5.2\ V.$

(b)

From eqn (1)

$$V_{GS} = 9.63 - I_D(750)$$

let $I_D = 0$

$$V_{GS} = 9.63$$

let $V_{GS} = 0$

$$I_D = \frac{9.63}{750} = 12.8\ mA$$

$$V_{DS} = V_{DD} - I_D(R_D + R_S)$$

$$= 23.8 - 3\ (2.2 + 0.75)$$

$$V_{DS} = 14.95\ V.$$

$$V_S = I_D R_S$$

$$= 3 \times 0.75$$

$$= 2.25$$

$$V_D = V_{DS} + V_S$$

$$= 14.95 + 2.25$$

$$= 17.2$$

$$V_{GD} = V_G - V_D$$

$$= 9.63 - 17.2$$

$$= -7.57\ V$$

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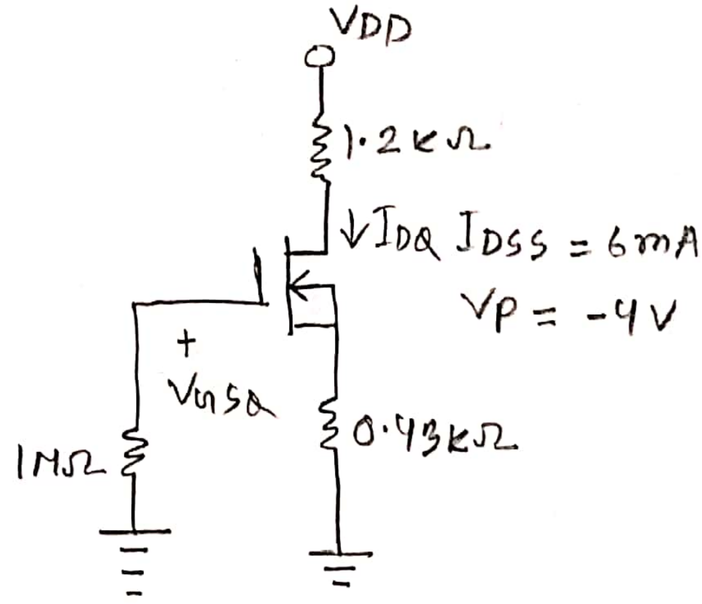
Q-4

(a)



Applying KVL,

$$-V_{GS} - I_D R_S = 0$$

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

$$= -I_D (0.43) \quad \cdots (1)$$

let's applying shorthand method

$$I_{DSS} = 6mA$$

$$V_P = -4V$$

1 → if $V_{GS} = 0$

$$I_D = I_{DSS} = 6mA$$

2 → if $V_{GS} = 0.3 V_P$

$$= 0.3(-4)$$

$$= -1.2V$$

$$I_D = \frac{I_{DSS}}{2}$$

$$= \frac{6}{2}$$

$$= 3$$

3 → if $V_{GS} = 0.5 V_P$

$$= 0.5(-4)$$

$$= -2$$

$$I_D = \frac{I_{DSS}}{4} = \frac{6}{4} = 1.5$$

4 → if $V_{GS} = V_P$

$$= -4V$$

$$I_D = 0$$

We know that

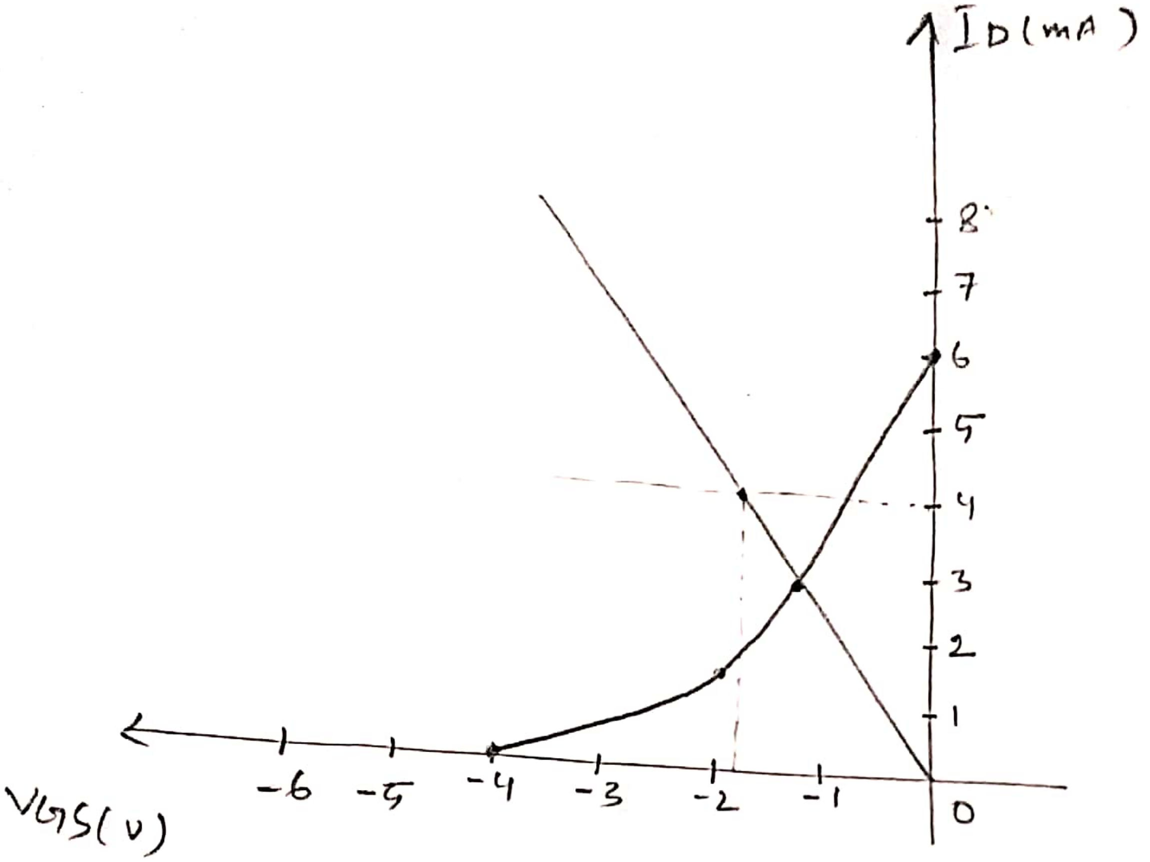
$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

$$V_{GS} = 1V$$

$$I_D = 6\left(1 - \frac{1}{-4}\right)^2$$

$$= 6 \times (1.5625)$$

$$= 9.375 \, mA$$



Now eq (1)

$$V_{GS} = -I_D(0.43)$$

$$I_D = 0, \quad V_{GS} = 0$$

$$I_D = 4$$

$$V_{GS} = 1.72.$$

(b) we know

$$V_{DS} = V_D - V_S$$

$$V_D = V_{DS} + V_S$$

$$V_{GS} = -I_D$$

$$I_D = 0,\ V_{GS} = 0$$

$$I_D = 6mA$$

$$V_{GS} = -4V$$

From Graph →

$$I_D = 4$$

$$V_{GS} = 1.72$$

$$V_{DS} = V_{DD} - I_D R_D - I_D R_S$$

$$= V_{DD} - I_D (R_D + R_S)$$

$$V_{DD} = (38 + 5) + 10$$
$$= 17.6$$

$$= 17.6 - 4(1.2 + 0.43)$$

$$= 17.6 - 6.52$$

$$= 11.08$$

$$V_S = I_D \times R_S = 4 \times 0.43 = 1.72$$

$$V_D = V_{DS} + V_S$$

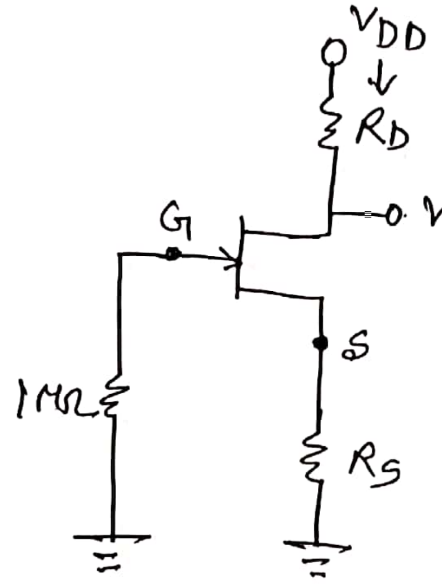
$$= 11.08 + (I_D \times R_S)$$

$$= 11.08 + (4 \times 0.43)$$

$$= 12.8$$

Ans.

Q-5



$I_{DSS} = 6mA$

$V_P = -3V$

$V_{DD} = (I_D \div 5) + 15$

$= (38 \div 5) + 15$

$= 22.6$

$I_{DQ} = (I_D \div 20)\, mA$

$= 38 \div 20$

$= 1.9$

(I) $V_{GS} = 0$

$I_{DSS} = 6mA$

(II) $V_{GS} = 0.3 V_P$

$= 0.3(-3)$ $\quad I_D = 3mA$

$= 0.9$

(III) $V_{GS} = 0.5 V_P$

$= 0.5(-3)$

$= -1.5V$

$I_D = 1.5mA$

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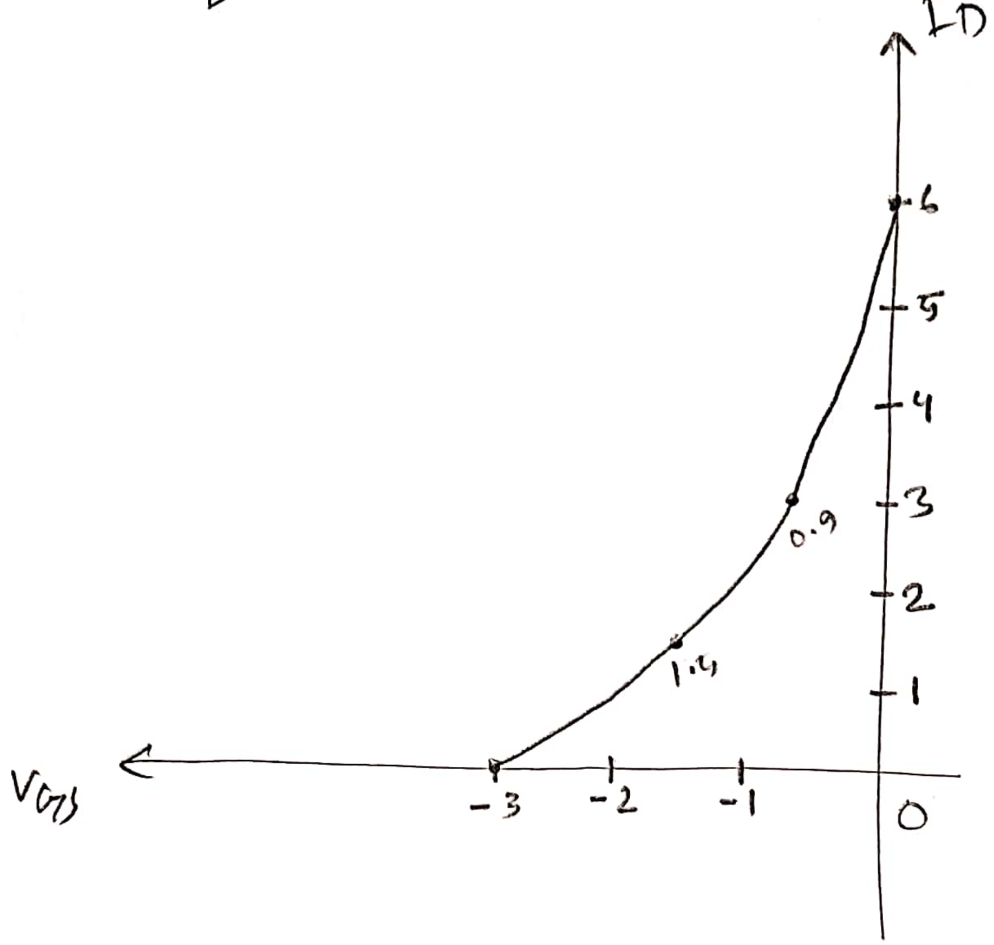
(v)

$V_{GS} = V_P$

$= -3$

$I_D = 0$



$V_S = I_D R_S$

$R_S = \frac{V_S}{I_D} = \frac{12}{6} = 2\,k\Omega$

$V_{DS} = V_{DD} - I_D \times R_D$

$12 = 22.6 - (1.9 \times R_D)$

$R_D = 5.57\ k\Omega$