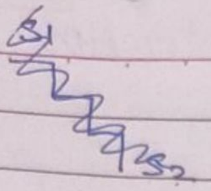
Assignment 1. (30 Aug.)

Q1. a)

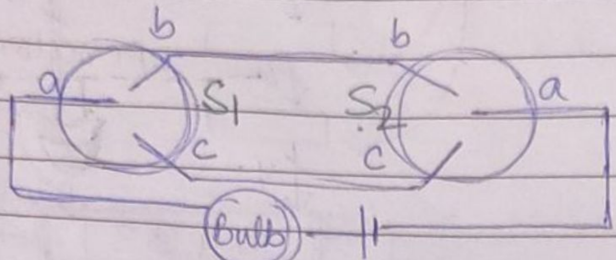


(Switch ON)

A	B	Out
0	0	0
0	1	1
1	0	1
1	1	0

} XOR gate.

(b)



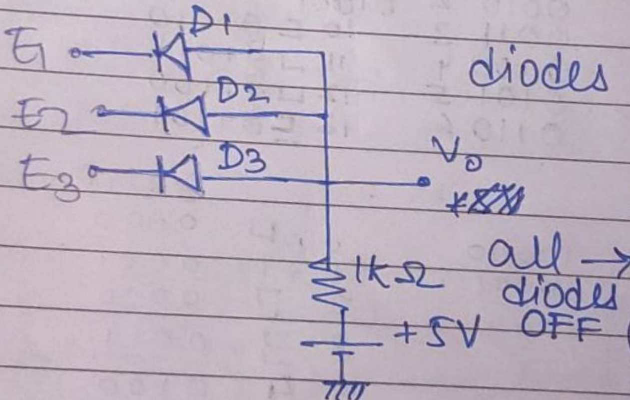
For always lighting of bulb → path unbroken.
both a connected to b or c.
ie. Both switch on or off.

$\Rightarrow S_1 \cdot S_2 + \overline{S_1} \cdot \overline{S_2}$

$\Rightarrow \overline{S_1 \oplus S_2}$ or $S_1 \odot S_2$

XNOR Gate.

Q2.

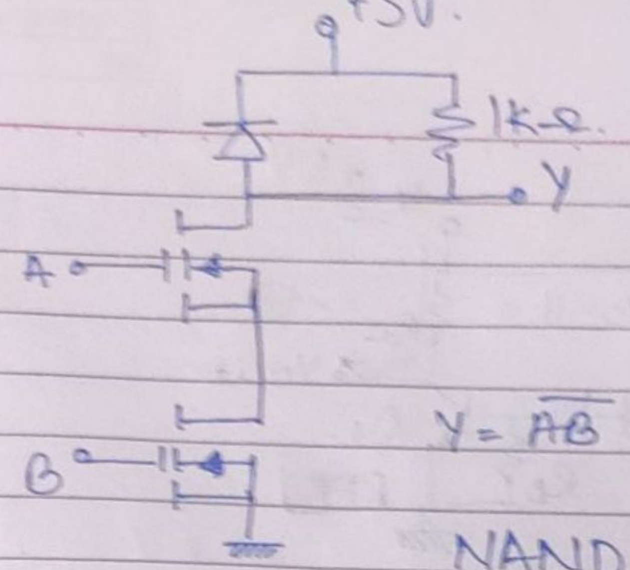


diodes are ideal.

	E_1	E_2	E_3	V_o
all diodes OFF →	1	1	1	1
	1	1	0	0
	1	0	1	0
	0	1	1	0
atleast any diode short circuited.	0	0	1	0
	1	0	0	0
	0	1	0	0
diodes ON. →	0	0	0	0

∴ AND Gate.

Q3(a)

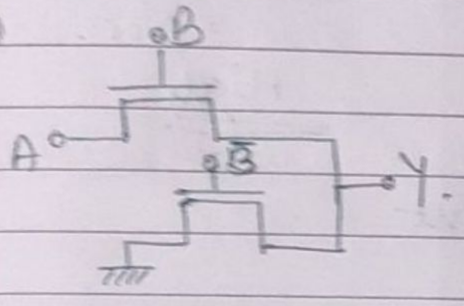


A	B	Y	nmos ON
1	1	0	∴ Y connected to ground.
1	0	1	n-mos OFF ∴ Y connected to +5V.
0	1	1	
0	0	1	

$Y = \overline{AB}$

NAND Gate

(b)



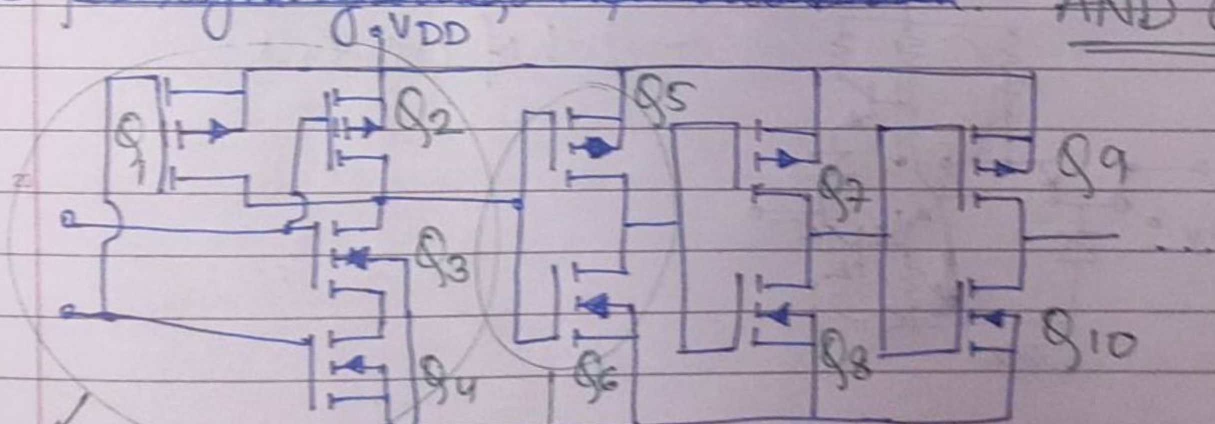
A	B.	Y
1	1	1
1	0	0
0	1	0
0	0	0

B=1, Y is connected to A

Y connected to ground

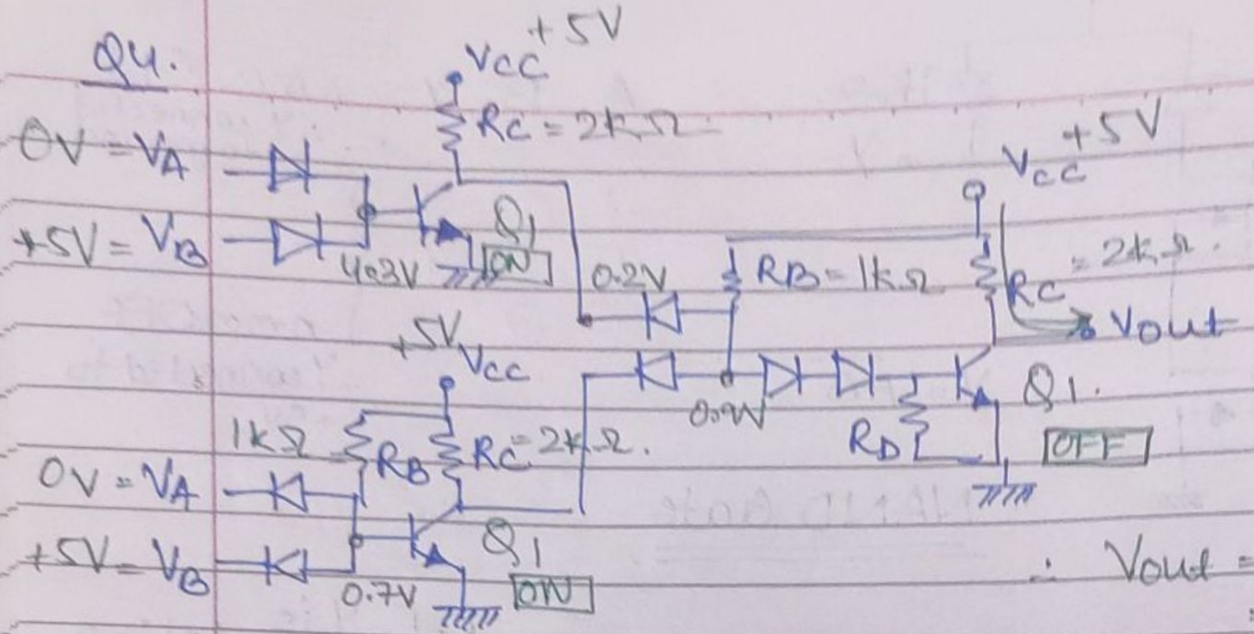
AND Gate $Y = AB$.

(c) ~~for high they both, ...~~ AND Gate



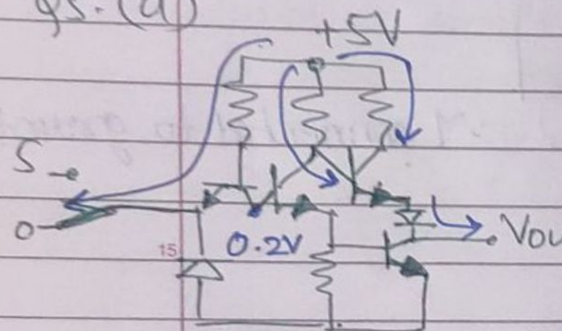
NAND + 3(inverters) → AND gate.

Q4.



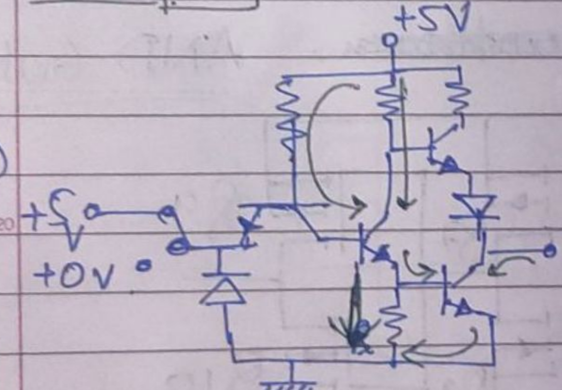
$\therefore V_{out} = +5V$
$= V_{cc}$.
High.

Q5. (a)



— path of current

(b)

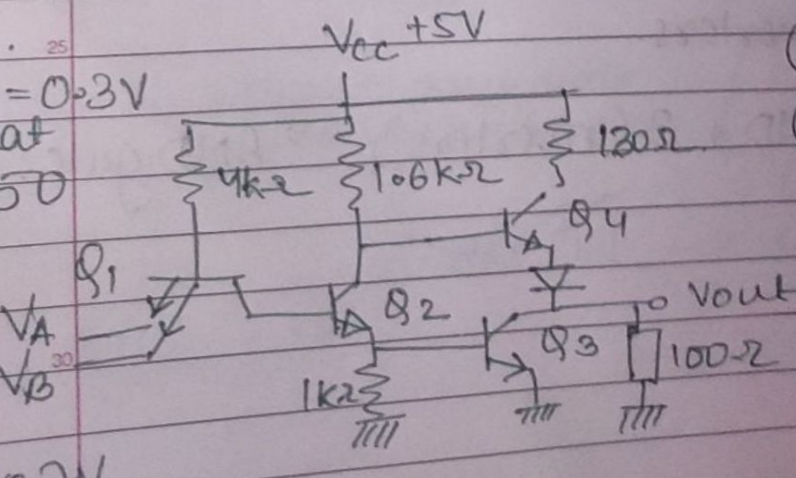


— path of current.

Q6.

$V_{CEsat} = 0.3V$

$h_{FE} = 50$

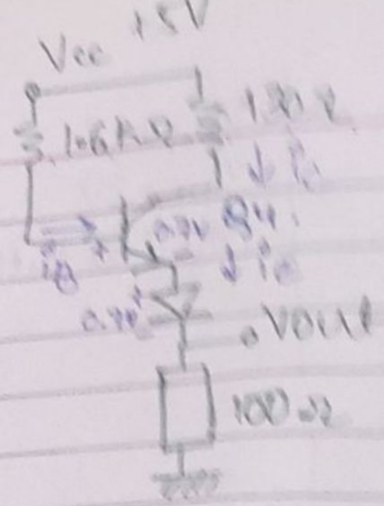


(a) $V_A = V_B = 0V$.

(b) $V_A = V_B = 5V$.

$V_D = 0.7V$

(a)



Both $V_A, V_B = 0$ Q_1, Q_3 OFF

KVL:

Assuming active
$i_c = \beta i_B$

$5 - 1600 i_B - 0.7 - 0.7 - 100 i_E = 0$
$3.6 = 1600 i_B + 5100 i_B$
$3.6 = 6700 i_B$
$i_B = 0.53 mA$

$i_C = 50 i_B$
$i_E = 51 i_B$.

$V_{CE} = V_C - V_E$
$= (5 - i_c 130) - (100 i_E + 0.7)$
$= -1.93 < V_{CE\,sat}$

$V_{CE\,sat} = 0.3V$

transistor is in saturation.

$5 - 1600 i_B - 0.7 - 0.7 - 100 i_E = 0$
$3.6 = 1600 i_B + 100 i_E$

$5 - 130 i_c - 0.3 - 0.7 - 100 i_E = 0$
$4 = 130 i_c + 100 i_E$

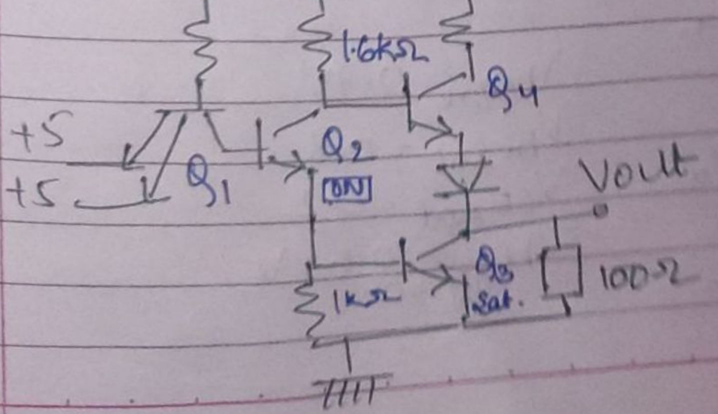
$V_{out} = 100 i_E$

$\therefore V_{out} = 3.6 V$

$V_{BQ_2} = 0.3V$
$Q_2 \longrightarrow$ OFF
$i_{c_{Q_2}} \simeq i_{B_{Q_1}} \simeq 0$.
$\therefore 3.6 = 100 i_E + 1600 i_E$

(b) $V_A = V_B = 5V$. Q_2 ON Q_3 (sat)

$\therefore V_{out} = 0.3V$



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Q7. $V_{OL} = 0.9V$ $\quad V_{IL} = 1.2V$
$V_{OH} = 4.5V$ $\quad V_{IH} = 3.2V$

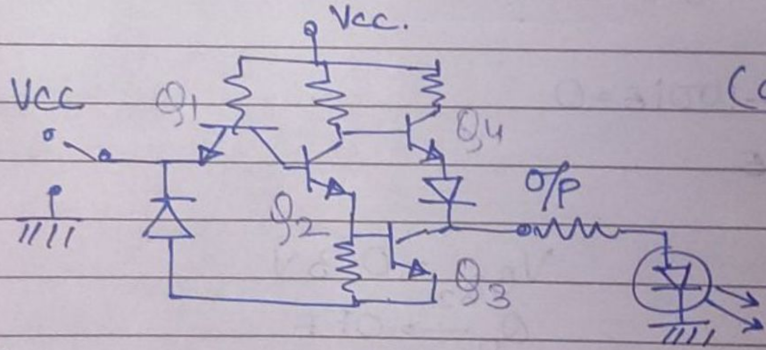
$N_{ML} = ?$ transition width = ?
$N_{MH} = ?$ Logic swing = ?

$V_{IL} = 1.5V$
$V_{IH} = 3V$
will it be better?

$N_{ML} = V_{IL} - V_{OL}$
$= 1.2 - 0.9 = 0.3V$
$N_{MH} = V_{OH} - V_{IH}$
$= 4.5 - 3.2 = 1.3V.$
transition width $= V_{IH} - V_{IL}$
$= 3.2 - 1.2 = 2V$
Logic swing $= V_{OH} - V_{IH}$
$= 4.5 - \cancel{0.9} \cancel{+.5}\ 3.6\ V.$

$N_{ML} = 0.6V$
$N_{MH} = 1.5V$
as noise margins is greater thus it would perform better.

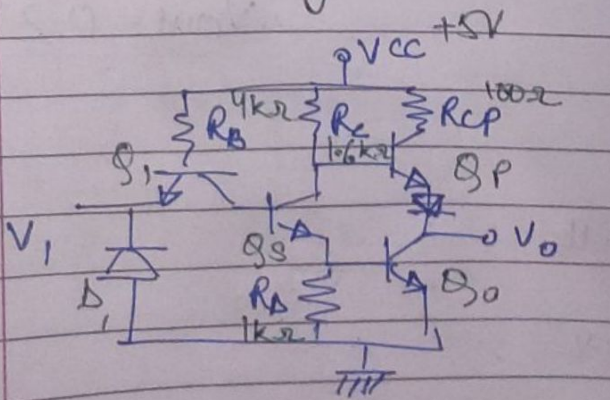
Q8.



(a) Switch on Vcc.
$Q_2 \to ON$
O/p low.
∴ LED doesn't glow

(b) Switch on 0V
$Q_2 \to OFF$ (as V_{base} $0.2 < 0.7$).
O/p high.
LED will glow.

Q9.



$V_{be\,on} = 0.7V$
$V_{be\,sat} = 0.8$
$V_{ce\,sat} = 0.2$
$V_{be\ off \to on} = 0.65V$

by inc. V_1 from $0 \to V_{cc}$.

$V_1 \in [0, 0.45]$

$Q_1 \to$ Saturation

$Q_2 \to$ OFF until $V_1 + 0.2 < 6.5$

$Q_0 \to$ OFF $\qquad V_1 \leq 0.45$

$I_{Rc} = I_{BP}$

$V_0 = V_{cc} - 0.7 - 0.7$

$= 3.6\,V$.

for high I_L, $Q_P \to$ saturates.

$V_0 = V_{cc} - 0.8 - 0.8$

$= 3.4\,V$.

after $V_1 \in [0.45, 1.15]$

$Q_S \to$ ON

$Q_1 \to$ saturation

$Q_0 \to$ OFF

$Q_P \to$ active.

$A_{VS} = \dfrac{-R_C}{R_D} = -1.6 \rightarrow V_i \in [0.45, 1.15]$

$Q_0 \to$ OFF until $V_{RD} \leq 0.65$

$Q_0 \to$ ON when $V_i + 0.2 - 0.7 - 0.65 = 0$

$V_i = 1.15$

$V_0 = V_{cc} - i_c R_c - 0.8 - 0.8$

$= 3.4 - 0.65 \times 1.6$

$V_0 = 2.36\,V$.

$V_{RD} = 0.65$

$i_{es} = 0.65\,mA$

$i_{cs} \simeq i_{es}$

$Q_S, Q_0 \to$ active

$Q_1 \to$ saturation

$Q_2 \to$ (active $\Rightarrow$ OFF)

$r_d \simeq 1\,k\Omega$

$\Delta V_0 = A_{VS} \Delta V_{BS} + A_{V_0} \Delta V_{B0}$

$A_V = A_{VS} + A_{V_0} = -6.8$

$A_{VS} = \dfrac{-R_C}{R_D \parallel r_d} = -3.2$.

$A_{V_0} = \dfrac{\Delta V_0}{\Delta V_{BQ_0}} = -\dfrac{\beta_F R_{C,eff}}{r_d} = \dfrac{-\beta_F}{r_d}\left(\dfrac{r_d + r_d + R_c}{\beta_F}\right) = -3.6$.

$Q_0 \rightarrow$ saturate at $V_{BE} = 0.8V$

$V_1 = 0.8 + 0.8 - 0.2$

$= 1.4 V.$

$V_0 = 0.2$

as saturation.

If $V_{in} \geq 1.4 V.$

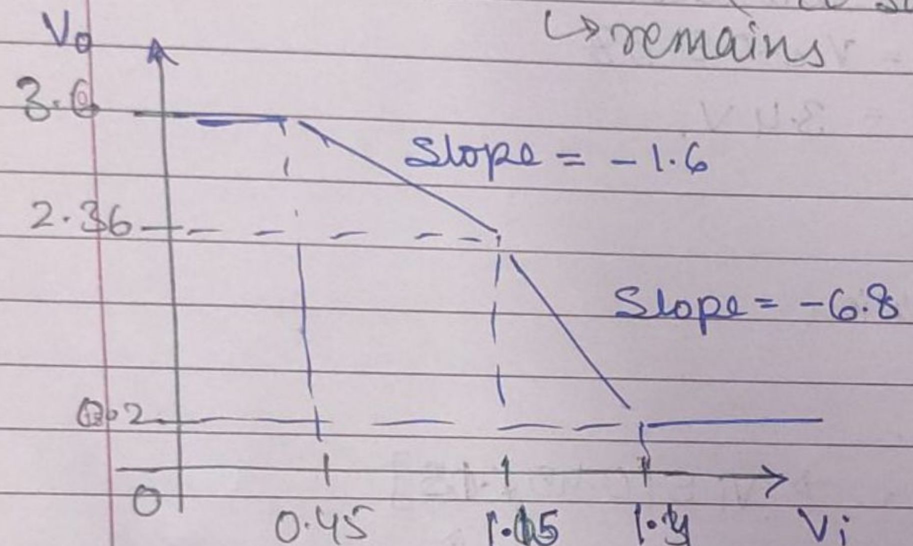
$Q_S, Q_O \rightarrow$ saturates.

$V_1 = 0.8 + 0.8 - 0.2$

$= 1.4.$

$V_0 = 0.2$ (V_{CE} saturation)

$\hookrightarrow$ remains



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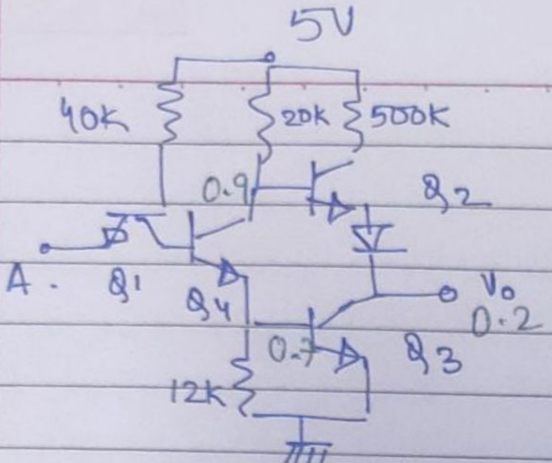
Q10.



Since o/p is low, i/p must be high.
Thus, Q_4, Q_3 are in saturation
$Q_2 \to$ OFF, $Q_1 \to$ inverse active mode

$$V_{B_{Q_3}} = 0.7V$$

$$V_{C_{Q_4}} = 0.2 + 0.7 = 0.9V$$

$$I_{C_{Q_4}} = \frac{5-0.9}{20} \text{ mA.}$$

$$I_{C_{Q_4}} = 0.205 \text{ mA.}$$