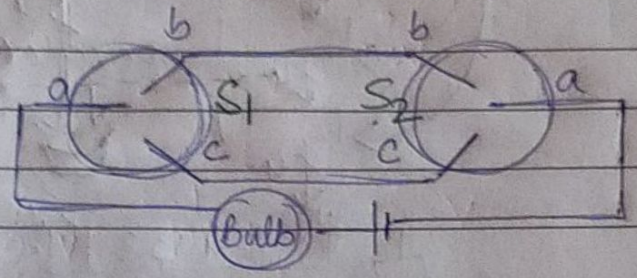
Assignment 1. (30 Aug)

Q1. a) S1 S2 (Switch ON)

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

} XOR gate.

(b)



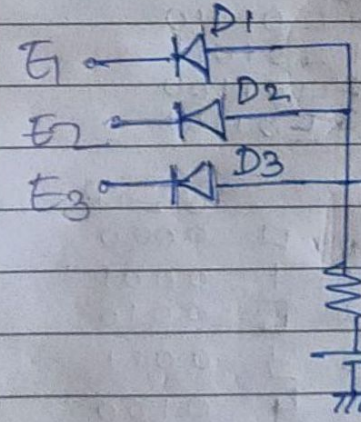
For always lighting of bulb → path unbroken.
both a connected to b or c.
ie. Both switch on or off.

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

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

XNOR Gate.

Q2.

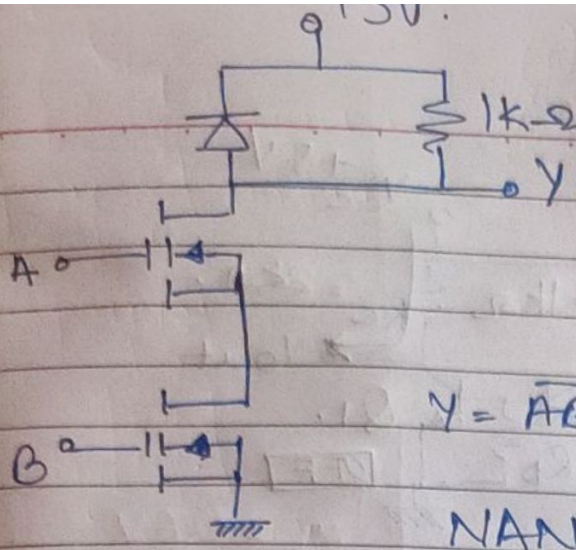


diodes are ideal.

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

∴ AND Gate

Q3(a)

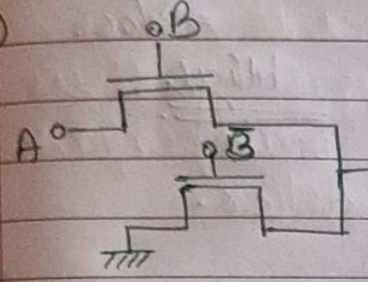


A	B	Y	nmos
1	1	0	ON ∴ Y connected to ground.
1	0	1	nmos OFF ∴ Y connected to +5V.
0	1	1	
0	0	1	

$Y = \overline{AB}$

NAND Gate

(b)



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

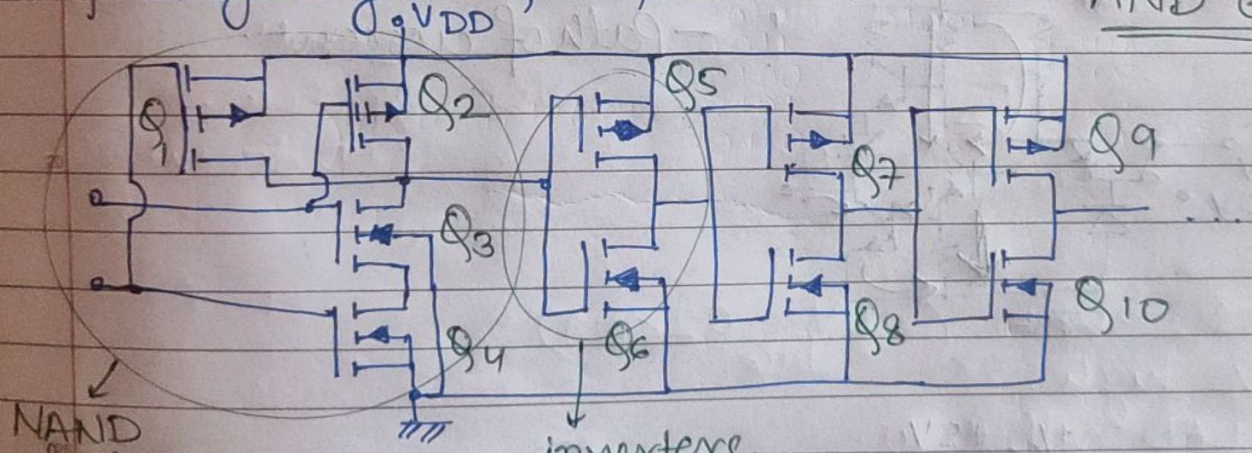
B=1, Y is connected to A

Y connected to ground.

AND Gate $Y = AB$.

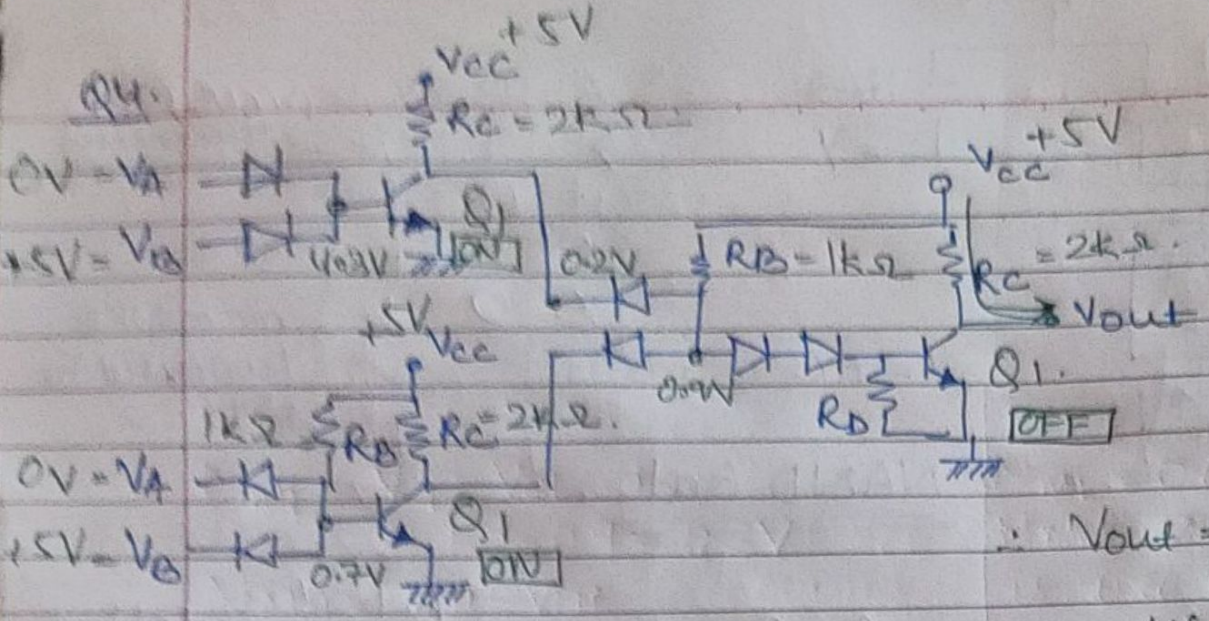
(c) ~~[illegible]~~.

AND Gate



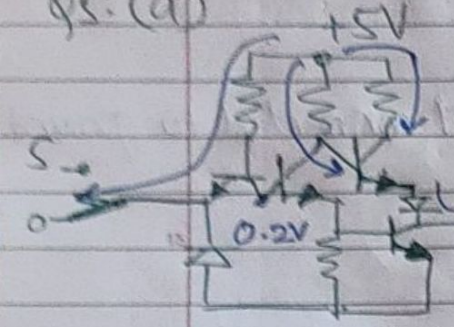
NAND + 3 (inverters) → AND gate.

Q4.



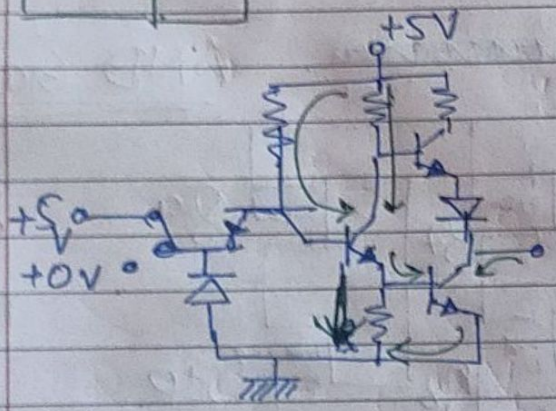
∴ Vout = +5V
= Vcc.
High.

Q5. (a)



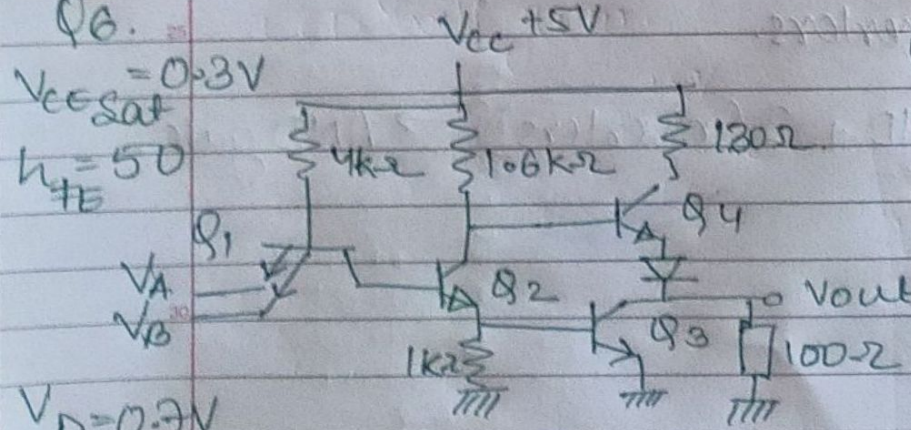
– path of current

(b)



– path of current.

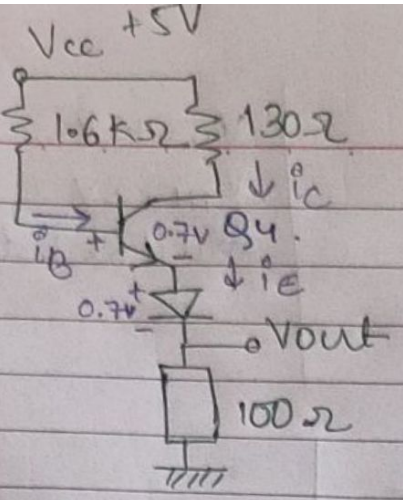
Q6.



(a) VA = VB = 0 V.

(b) VA = VB = 5V.

(a)



$i_C = 50 i_B$

$i_E = 51 i_B$

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

Both $V_A, V_B = 0$. $Q_2, Q_3 \rightarrow$ OFF.

KVL: assuming active region.

$i_C = \beta i_B$.

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

$3.6 = 1600 i_B + 5100 i_B$

$3.6 = 6700 i_B$

$i_B = 0.537 mA$

$V_{CE} = V_C - V_E$

$= (5 - i_C \cdot 130) - (100 i_E + 0.7)$

$= -1.93 < V_{CE\,sat}$

transistor is in saturation.

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

$3.6 = 1600 i_B + 100 i_E$

$5 - 130 i_C - 0.3 - 0.7 - 100 i_E = 0$

$4 = 130 i_C + 100 i_E$

$V_{out} = 100 i_E$

$\therefore V_{out} = 3.6\,V$

$V_{BQ_2} = 0.3V$

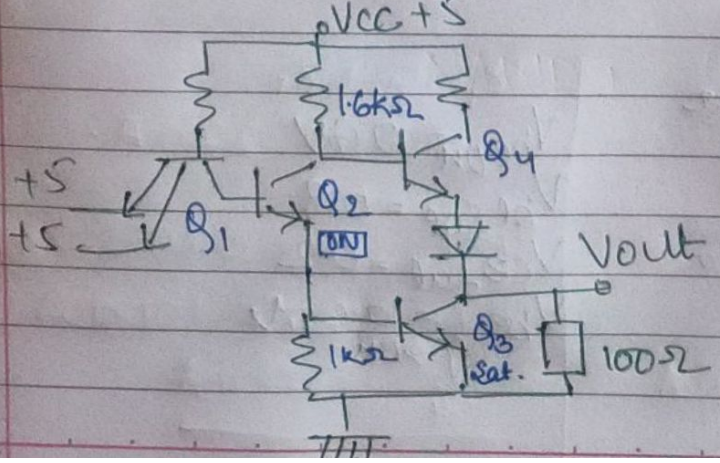
$Q_2 \rightarrow$ OFF

$i_{C_{Q_2}} \cong i_{B_{Q_1}} \cong 0$.

$\therefore 3.6 = 100 i_E + 1600 i_B$ ~~0~~.

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

$\therefore V_{out} = 0.3V$.



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

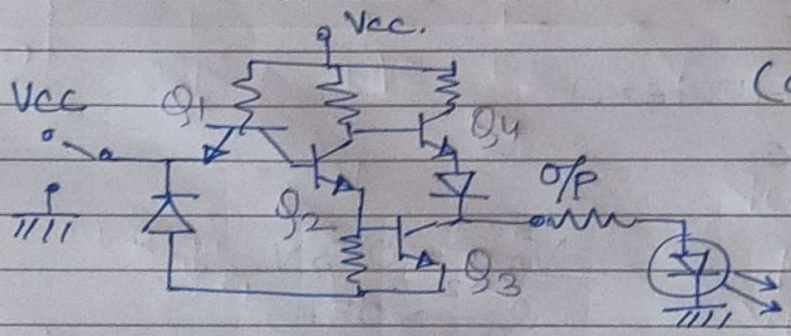
$N_{ML} = ?$ transition width = ?
$N_{MH} = ?$ logic swing = ?

$V_{IL} = 1.5V$
$V_{IH} = 3V$
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 $= V_{OH} - V_{IH}$
$= 4.5 - 3.6 V.$

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

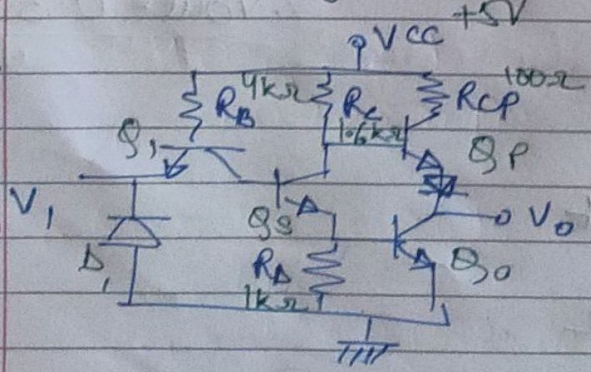
Q8.



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

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

Q9.



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

by inc. V_1 from 0 → Vcc.

$V_1 \in [0, 0.45]$

Q_1 → Saturation

Q_2 → OFF until $V_1 + 0.2 < 6.5$

Q_0 → OFF $\quad V_1 \leq 0.45$

$I_{RC} = I_{BP}$

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

$= 3.6\ V.$

for high I_L, Q_P → saturates.

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

$= 3.4\ V.$

after $V_1 \in [0.45, 1.5]$

Q_S → ON

Q_1 → saturation

Q_0 → OFF

Q_P → active.

$A_{VS} = \frac{-R_C}{R_D} = -1.6$ → $V_i \in [0.45, 1.05]$

Q_0 → OFF until $V_{RD} \leq 0.65$

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

$V_i = 1.15$

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

$= 3.4 - 0.65 \times 1.6$

$V_0 = 2.36\ V.$

$V_{RD} = 0.65$

$i_{es} = 0.65\ mA$

$i_{cs} \approx i_{es}$

Q_S, Q_0 → active

Q_1 → saturation

Q_2 → (active ⇒ OFF)

$\Delta V_0 = A_{VS} \Delta V_{BS} + A_{V_0} \Delta V_{B_0}$

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

$r_d \approx 1\ k\Omega$

$A_{VS} = \frac{-R_C}{R_D \| r_d} = -3.2.$

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

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

$V_1 = 0.8 + 0.7 - 0.2$

$= 1.3V.$

$V_0 = 0.2$ as saturation.

If $V_{in} \geq 7.3V$.

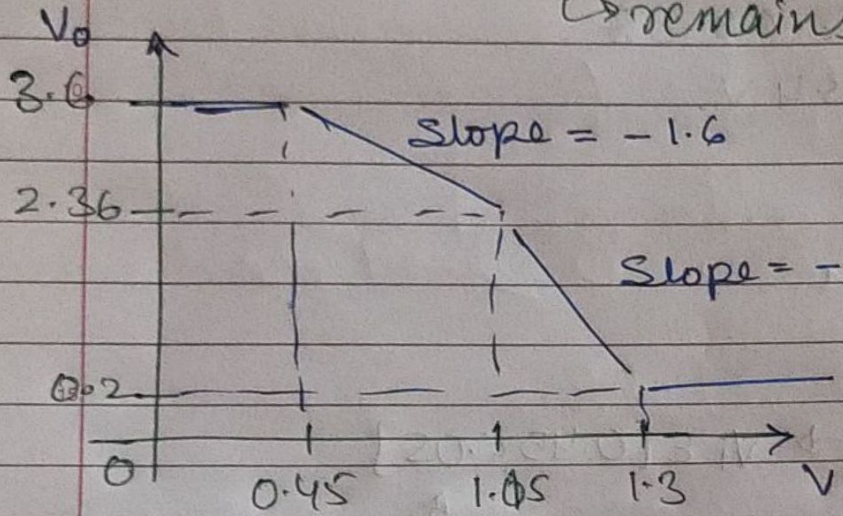
$Q_5, Q_0 \rightarrow$ saturates.

$V_1 = 0.8 + 0.8 - 0.2$

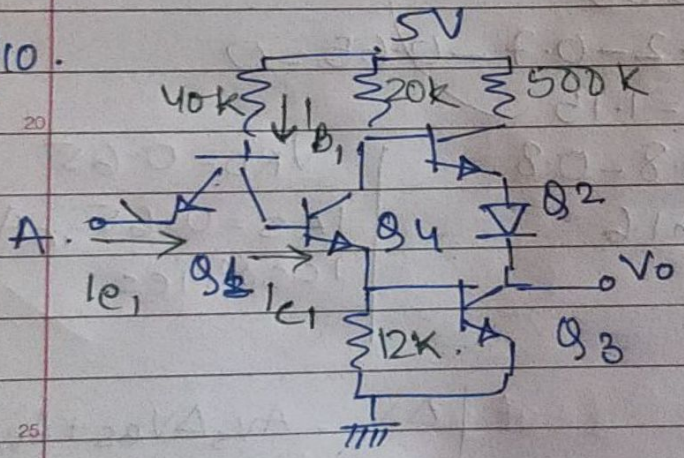
$= 1.4.$

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

↳ remains



Q10.



$V_{CE\,sat} = 0.2$

$\beta = 100.$

$V_{BE\,sat} = 0.7.$

$\alpha = 0.01$ (Q_1).

inverse active mode

$5 - 40 i_{B_1} = 2.1$

$i_{B_1} = 0.0725 mA.$

$\alpha Q_1 = \frac{i_{e1}}{i_{B_1}} = 0.01.$

$i_{e_1} = \frac{1}{100} \times 0.0725 mA.$

$i_{c_1} = i_{B_1} + i_{e_1}$

$= 0.07322 mA.$

$i_{B4} = i_{C_1} = 0.07322 mA$

$i_{C4} = \beta i_{B4} = 100 \times 0.07322$

$i_{C_4} = 7.322 mA$